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The cranial anatomy of the marl-cheeked fishes,
By Edward Phelps Allis, Jr.

the lachrymal bone by the single large aperture on the dorso-anterior edge of that bone. The canal then traverses the lachrymal, giving off two primary tubes in its course, these tubes opening on the outer surface by small groups of pores which lie one between the anterior and next posterior spine of the bone, and the other between this latter spine and the next posterior one. The fourth tube of the line leaves the canal as it passes from the lachrymal into the first suborbital, and the fifth tube as it passes from that bone into the second suborbital, these tubes both opening on the outer surface by small groups of pores that lie ventral to the canal.

In the second suborbital (third infraorbital) the canal runs backward nearly to the hind edge of the bone, where it issues from the bone on its external surface and ends, having given off one primary tube in its course. This latter tube is the 6th. tube of the line, the canal ending in a terminal tube which represents one half of the 7th. tube of the line, as will be further explained below. These two tubes lie rather close together, near the hind edge of the bone, the 6th. tube directed postero-ventrally and the 7th. one postero-dorsally. Both tubes open on the outer surface by a group of pores, and certain pores of the 7th. group had secondarily fused, in all the several specimens examined, with certain pores of the penultimate dendritic system of the preopercular canal, a dermal communication between the hind end of the suborbital section of the main infraorbital canal and the preopercular canal thus here being established. This communication is large and important, and one not thoroughly conversant with this subject might naturally be led to say, as Garman ('99) has said of Ectreposebastes imus, that the postorbital portion of the main infraorbital canal and the dorsal portion of the preopercular canal were here „reduced to a single canal". This however would certainly be, if said of Scorpaena, and must also be of Ectreposebastes, a most misleading statement of the case, for the two main canals themselves do not in any sense here run into each other, a certain pore or pores of a dendritic system of one of them simply anastomosing, secondarily, with a certain pore or pores of a dendritic system of the other.

Beyond the 7th. primary tube, the main infraorbital canal is interrupted, the next posterior section of the canal being enclosed in the little postorbital ossicle, and not having any direct connection with the suborbital portion of the line. The 7th. tube of the line is thus the terminal tube of an anterior, suborbital portion of the line, and is the anterior half, only, of what would be the 7th. primary tube of a continuous canal. The other half of this primary tube lies directly behind the eye, at the ventral edge of the little postorbital ossicle, and forms the anterior tube of the postorbital section of the canal. In some specimens the dendritic system formed by the repeated subdivisions of this posterior half of the 7th. primary tube seemed to be in secondary communication with the penultimate system of the preopercular canal, but, in the one wholly satisfactory preparation made, this connection did not exist. The dissection necessary to establish this is a difficult and delicate one, and the use of injecting fluids is usually misleading, for the delicate walls of the tubes are easily broken down and artificial connections thus established.

Starting from the posterior half tube of the 7th. primary system of the line, the canal runs upward through the postorbital ossicle and then traverses the relatively wide interval between this ossicle and the postfrontal bone, there lying immediately beneath the thin dermis. From this part of the canal the 8th. primary system of the line arises, this system being a large and complicated one, and having much more the appearance of two half systems that have secondarily anastomosed than of two half tubes that have completely fused to form a single tube and system. The branches of this system extend backward across the cheek, and one of them anastomosed, in all of the spec-

imens examined, with the double dendritic system formed where the terminal tube of the preopercular canal anastomoses with the main infraorbital; a second, or third secondary connection thus here being established between these two canals.

Beyond the 8th. dendritic system the canal enters and traverses the postfrontal, at the hind end of which bone it anastomoses with the penultimate tube of the supraorbital canal, a small double system here arising from the canal. The canal then turns backward and traverses the pterotic, at the hind end of which bone it anastomoses with the dorsal end of the preopercular canal, giving rise to a double system, 10 inf.-12 pmd. This double system had, in the one satisfactory dissection made, separated into two parts, one lying dorsal and the other ventral to the main infraorbital canal. The dorsal one of these two portions was small, and opened on the outer surface in a small group of pores, the ventral one being large and undergoing anastomosis not only with the 8th. infraorbital system, as above described, but also with the 11th. system of that same line. This last anastomosis gives rise to a large and complicated system which spreads backward in the dermis that covers the levator operculi muscle, extending even beyond that muscle onto the dorsal portion of the outer surface of the opercular.

Posterior to the 10th. tube of the line, the main infraorbital canal traverses the lateral extrascapular and then the suprascapular and supraclavicular, the 11th. tube of the line being given off between the first two bones, the 12th. tube between the last two, and the 13th. tube at the hind end of the supraclavicular. The 11th. tube gives rise, as just above stated, to a large dendritic system which anastomoses with the ventral half of the double system 10 inf.-12 pmd. The 12th. and 13th. systems are small.

In the full length of the main infraorbital canal there are twelve sense organs, one organ thus being found between each two consecutive primary tubes. Three of these organs lie in the lachrymal, one in the first suborbital, two in the second suborbital, one in the postorbital ossicle, and one each in the postfrontal, pterotic, lateral extrascapular, suprascapular and supraclavicular. The first six organs of the line are each innervated by consecutive and independent branches of the ramus buccalis facialis. The eighth (postfrontal) and ninth (pterotic) organs are innervated by branches of the ramus oticus facialis. The innervation of the 7th., or postorbital organ could not be determined either in the sections or the dissections, but it is quite unquestionably innervated by a nerve that corresponds to that somewhat independant branch of the buccalis that innervates, in Amia, the posterior group of buccal organs of that fish. If this be so, the postorbital break in the main infraorbital canal occurs between two groups of organs of the line, and is strictly similar to the break found in this same line in Batrachus tau (Clapp, '98) and Chimaera monstrosa (Cole, '96), and to which I have made full reference in several of my works.

The 10th. (extrascapular) and 11th. (suprascapular) organs are innervated by branches of the supratemporal branch of the nervus lineae lateralis vagi; the 12th. (supraclavicular) organ being innervated by the first single branch of the latter nerve.

The supratemporal canal arises from the main infraorbital canal as that canal traverses the lateral extrascapular. Running mesially it traverses the lateral extrascapular and then the parieto-extrascapular, and then unites, in the mid-dorsal line, with its fellow of the opposite side, thus forming a complete cross-commissure. As the canal passes from the lateral extrascapular into the parieto-extrascapular it gives off a primary tube which separates into two parts one directed anteriorly and the other posteriorly and both giving rise to relatively important dendritic systems. A similar

system arises where the canals of opposite sides anastomose in the mid-dorsal line. The canal contains two sense organs, one lying in the lateral extrascapular and the other in the parieto-extrascapular; both organs being innervated by branches of the supratemporal branch of the nervus lineae lateralis vagi.

The supraorbital canal begins at the anterior end of the nasal, traverses that bone, and then runs backward in the frontal nearly to its hind edge. The anterior dendritic system of the line lies at the anterior end of the nasal and is represented by a small and somewhat scattered group of pores. The 2nd. system of the line arises from the canal as it passes from the nasal into the frontal. It is larger than the first system and sends a long branch laterally and downward in the dermal bridge between the two nasal apertures. This branch opens on the outer surface by several pores, and in one specimen, as already stated, one of these pores seemed to have anastomosed with a pore or pores of the anterior dendritic system of the main infraorbital line, thus here establishing a connection between these two lines. The 3rd., 4th. and 6th. systems all arise from that part of the canal that lies in the frontal, the canal then ending while still in that bone, in the 7th. or terminal system of the line. The 5th. system, which should normally be formed between the 4th. and 5th. organs of the line, is wholly wanting even in the young specimens examined in sections. The trunk of the 3rd. system is directed forward, and branching gives rise to an elongated group of from twelve to eighteen pores. The trunk of the 4th. system is directed postero-mesially and traverses the frontal to its mesial edge, where it anastomoses with its fellow of the opposite side to form the frontal (supraorbital) cross-commissure. The single median pore here first formed by the fusion of the single primary pores of opposite sides has, by subsequent division, given rise to a small median group of pores. The trunk of the 6th. system runs postero-laterally in the frontal, to its lateral edge, where it anastomosed with the 9th. trunk of the main infraorbital to form a double system. Having given off this trunk, the canal turns posteriorly and issues from the frontal beneath the frontal spine, the 7th. or terminal system of the line being represented by a circular group of some ten to fifteen pores.

The supraorbital canal contains six sense organs, this being one more than is warranted by the number of dendritic systems actually found in the fish. One of these organs lies in the nasal, and five in the frontal. The organ in the nasal is normal in its relations to the trunks of the dendritic systems, as are also the first two organs in the frontal; one of these latter organs lying between the trunks of the 2nd. and 3rd. systems of the line and the other between the trunks of the 3rd. and 4th. systems. The fourth organ lies partly opposite and partly posterior to the trunk of the 4th. system, the fifth organ being similarly related to the trunk of the 7th. or terminal system. The sixth organ is a small one lying in the trunk of the 7th. or terminal system of the line. Between the fourth and fifth organs there is no primary tube in Scorpaena, but both in Cottus scorpius and Cottus octodecimospinosus there is here a small tube. As, otherwise, the organs and tubes are exactly similar in the three fishes, a tube has certainly either aborted or never been developed, in Scorpaena, between the fourth and fifth organs of the line. These two organs lie quite close together and are innervated by branches of a single branch of the ophthalmicus lateralis, the other organs of the line all being innervated by independent branches of the same nerve. The nerve that innervates organs 4 and 5 perforates the frontal, at the base of its ventral flange, to reach the organs it supplies, sometimes separating into its two parts external to the frontal and sometimes while traversing that bone. In one young specimen examined in serial sections the branch to organ 5 separated

from the branch to organ 4 after the main branch had entered the main infraorbital canal itself, and then continued its course inside that canal. This all certainly indicates that organs 4 and 5 lie so close together at the time that they become enclosed in the canal that no primary tube can be developed between them, this tube thus never being formed. In Menidia also these two organs lie close together (Herrick, '99, p. 198), but there is a primary tube between them as there is in Cottus. In Gadus (Cole '98) there is, as in Scorpaena, no primary tube between the 4th. and 5th. organs of the supraorbital canal, but Gadus differs from Scorpaena in that there is no 6th. supraorbital organ and related primary tube.

Organ 6 of Scorpaena differs from the other organs of the line in being much smaller than any of them. It is innervated by the first branch of the ophthalmicus lateralis, this branch perforating the alisphenoid from its lateral surface and then running upward inside the cranial cavity to perforate the frontal immediately beneath the organ it supplies.

The preoperculo-mandibular canal begins near the symphysis of the mandible, and, running posteriorly, traverses the dentary, articular and preopercular, and then anastomoses with the main infraorbital canal at the hind end of the squamosal. The canal lodges eleven sense organs, four lying in the dentary, one in the articular and six in the preopercular, all of them innervated by branches of the ramus mandibularis externus facialis. A primary tube arises from the canal between each two consecutive organs, this making, with the two terminal tubes, twelve tubes in all. The eleventh tube anastomoses secondarily, as already stated, with the seventh tube of the main infraorbital canal, the twelfth tube anastomosing primarily with the tenth infraorbital tube and secondarily with the eighth and eleventh tubes of the same line.

6. NERVES.

The investigation of the nervous system of the several fishes of the group has been mainly limited to the adult of Scorpaena scrofa, and to serial sections of small specimens of that fish and of Lepidotrigla aspera; but certain features of the innervation in the adults of Cottus octodecimospinosus and Trigla hirundo, in small specimens of Dactylopterus volitans, and in embryos of Cottus scorpius have been also somewhat carefully examined. The intention at first was to simply determine the relations of the roots, ganglia and proximal portions of the cranial nerves to the skeletal elements, the study of the skeleton being the principal object of the research; but as certain of the series of sections examined permitted the tracing, with comparative accuracy, of the components of the several nerves, these results, so far as obtained, are given. There was however no attempt whatever to make these results complete. So far as given they are intended to be correct.

In recent English and American works on the cranial nerves of the lower vertebrates there is a marked tendency to consider the central origin of a given cranial nerve of much more importance for the determination of its segmental position than the course of the nerve and its general relations to the skeletal elements. Underlying this manner of considering the subject, is the implied acceptance of the neurone theory of the nervous system, according to which theory all nerve fibers grow either centrifugally or centripetally between two primarily disconnected points, choosing always the path of least resistance. Directly opposed to this manner of considering the subject is the earlier conception of the nervous system, recently re-presented by Gaskel ('05), according to which the peripheral and central cells are from the very beginning, and as soon as they begin their separate exis-

tence, always connected by nervous tissue. While my own work has never yet led me to investigate, or even to seriously consider, the manner in which the cranial nerves develop, it has led me to conclude, as I have already had occasion to state, that; (I) the relations of the nerves to the skeletal elements are so remarkably constant that if the nerve itself does not exist from the very beginning, some tissue or condition of tissue, defining its path, or some markedly strong inherited tendency must certainly so exist; and (2), that whenever a nerve is deflected from its accustomed and apparently predetermined path, careful examination and consideration will almost always show that it has simply been pushed or pulled one way or the other, surrounded to a different extent or in a different manner by the encroaching and enveloping growth of adjacent tissues, or even actually displaced relative to certain tissues or structures by a variation in the relative time, or in the relative degree of development of the nerve and those other tissues. That there are certain apparently inexplicable exceptions to this rule, I know full well.

According to the latter of these two conceptions of the nervous system, the general course of a nerve and its relations to the skeletal and other elements, properly determined, definitely define the segmental position of the nerve, and its centers of origin must be in accord with those determinations.

According to the other conception, carried to its legitimate extreme, the course of nerve fibers is not necessarily segmental, and, the terminal distribution of sensory fibers also not being necessarily segmental, the only positive criterion of the segment or segments to which the component fibers of a certain nerve belong is their points of origin in the central nervous system. Furthermore, the cranial segment to which it is assumed that certain fibers must necessarily belong having been determined by their central origin, the elements of accident, individual experience, or even a sort of elective selection are introduced as natural and constant occurrences to explain the apparently unsegmental peripheral course of certain of those fibers; and where certain sensory fibers are assumed, in the wording of the descriptions, to grow centripetally from certain sense organs to the brain, the same elements of accident, experience or elective selection may determine their peripheral course in one segment and their central origin in another. It is needless to refer to the many expressions and statements that seem to lead legitimately to these conclusions, and while these statements definitely impress the reader it is possible that they may not always give correctly the definite opinions of the authors making them.

These two radically different conceptions of the origin and development of the peripheral nervous system lead, frequently, to totally different interpretations of the facts of distribution, this being especially marked in relation to the branches of the trigemino-facialis complex. Stannius, apparently an advocate of the earlier conception of the nervous system, assigned the fibers of this complex to the trigeminus or facialis nerves according as they issued from the skull by one set of foramina or another, or had a distribution to what he considered as trigeminus or facialis regions; and he accordingly considered the roots of the complex as partly trigeminus, partly facialis, and partly mixed. Later authors first assigned all the lateralis fibers of the complex to the facialis, irrespective of their course and distribution, and now, still later, recent advocates of the component theory assign all the communis fibers also to that same nerve. I, myself, have accepted and advocated the assigning of the lateralis fibers of the complex to the facialis, but as I am not prepared to accept the assigning of the communis fibers to that nerve, I begin to doubt the justice of so assigning the lateralis ones. This will be further discussed when describing certain of the branches of the complex. To avoid confusion I still adhere to the nomen-

clature heretofore adopted in my works, excepting only as it relates to the lateralis nerves. In referring to these nerves I shall replace facialis by lateralis, and refer to the so-called dorsal and ventral lateralis roots of the trigemino-facialis complex as the lateralis trigemini and lateralis facialis respectively. The brain is not described, as no special examination of it was made.

NERVUS OLFACTORIUS.

The nervus olfactorius arises in Scorpaena from the anterior end of a lobus olfactorius which, as Stannius ('49) has said for Cottus and Trigla, lies beneath the anterior end of the cerebral hemisphere. The nerve is long and relatively slender, and the two nerves run forward, close together, a certain distance in the cranial cavity, there lying immediately dorsal or dorso-mesial to the nervi optici. The two nerves then enter a small median recess in the membrane that closes the orbital opening of the brain case. From this recess a membranous tube leads forward on either side of the posterior, membranous portion of the interorbital septum, each tube conducting the corresponding nervus olfactorius into the orbit. There the nerve continues forward along the lateral surface of the cartilaginous portion of the interorbital septum, passes dorsal to both of the oblique muscles, close to their origins, and traversing the olfactory canal in the antorbital process reaches the nasal pit.

In Menidia the olfactorius is said by Herrick ('99, p. 239) to be „crowded under the m. obliquus superior near its origin", which if it means that the nerve passes ventral to the muscle, must be exceptional for fishes (Stannius, '49, p. 7).

No indication of Locy's ('05) nervus terminalis could be found in any of the fishes of the group.

NERVUS OPTICUS.

The nervi optici are large and much pleated in all of the fishes of the group, as Stannius has already stated for Cottus and Trigla. In Scorpaena, as well as in Cottus, Sebastes and Trigla (Stannius), the chiasma is a simple crossing of the nerves, the left nerve lying dorsal to the right one in all the specimens examined, excepting in one specimen of Scorpaena. In that one specimen the right nerve was the dorsal one.

Beyond the chiasma the nerve of either side, in Scorpaena, runs almost directly forward in the cranial cavity until it reaches the anterior edge of the basisphenoid, where it turns antero-laterally, pierces the membrane that closes the orbital opening of the brain case and, entering the orbit, courses onward to the eyeball.

NERVUS OCULOMOTORIUS.

The nucleus of the nervus oculomotorius lies near the median line, mostly ventral to the fasciculus longitudinalis dorsalis, but, as in Menidia, partly dorsal to it. The fibers from the dorsal portion run downward mesial to the fasciculus and, joining the other fibers, turn ventro-laterally and issue from the base of the brain dorsal to the hind end of the lobus inferior. From there the nerve runs forward along the lateral surface of the dorsal portion of the lobus inferior, lying at first ventro-mesial to the nervus trochlearis and then in similar relation to the profundus ganglion and truncus ciliaris profundi. In one instance the nerve was, in part of its course, closely applied to the mesial surface of the communis ganglion of the trigemino-facialis complex. While still in the cranial cavity it separates into its superior and inferior divisions, both of which issue through the oculomotorius foramen in the proötic, usually alone, but in one 55 mm specimen, and on one side of the adult specimen used for figure No. 28 accompanied by the truncus ciliaris profundi.

Issuing from its foramen the nerve lies antero-dorsal to the rectus externus and postero-ventral to the rectus superior, to which latter muscle the superior division of the nerve immediately passes. The inferior division of the nerve then comes into close contact with the ciliary ganglion, and there immediately separates into two portions, the larger one of which is the branch for the recti inferior and internus and the smaller one the branch for the obliquus inferior. The larger branch immediately separates into its two parts, both of which run forward postero-ventral to the rectus superior, the branch to the rectus inferior immediately entering its muscle, while the branch to the rectus internus passes dorsal to the rectus inferior to reach its muscle. The ciliary ganglion lies upon the branch that goes to the recti internus and inferior and is connected with it by fibers which represent the radix brevis. The branch to the obliquus inferior turns downward and forward anterior to the rectus externus but postero-ventral to the other three recti muscles, and so reaches its muscle.

The branches of the oculomotorius and their relations to the recti muscles and the nervus opticus, are thus exactly as in Scomber.

In Lepidotrigla and Cottus the same arrangement is found; and Dactylopterus differs only in that the oculomotorius separates into three parts while still inside the cranial cavity, one branch destined to the rectus superior, one to the obliquus inferior, and the other to the recti inferior and internus. In Cottus, there being no basisphenoid, the nerve, as it issues from the cranial cavity, pierces the membrane that closes the orbital opening of the brain case, instead of there being enclosed in bone.

NERVUS TROCHLEARIS.

The trochlearis has a central origin and intracerebral course similar to that given by Herrick for this nerve in Menidia, and it issues from the brain along the ventral margin of the lobus opticus. Running forward in the cranial cavity it does not come into close relations with any of the roots of the trigeminus, or with nerves arising from those roots, differing, in this, from the nerve in Menidia. This is also true of Lepidotrigla, Cottus and Dactylopterus.

The nerve issues from the cranial cavity either along or through the edge of the alisphenoid, and running dorsal to all the muscles of the eyeball enters and supplies the obliquus superior.

NERVUS ABDUCENS.

The abducens issues from the ventral surface of the medulla oblongata slightly posterior to the lobus inferior, and between or slightly anterior to the anterior roots of the nervi acustici of opposite sides. In all the young specimens of Scorpaena examined, it arose by a single root, but in the adult specimen used for figure 28 it arose by two roots. In all of the specimens of Lepidotrigla examined it arose by two roots, one slightly posterior to the other, as Stannius has said for Trigla and Cottus. The one or two rootlets have their origin in a nucleus which lies, as in Menidia, at some distance from the median line and at about one third the distance from the ventral surface of the medulla to the floor of the overlying ventricle. A strong tract of fibers crosses transversely between the nuclei of opposite sides, but my sections did not give any indication either of the tract or the bundle of fibers, described by Herrick in Menidia, that runs from the nucleus or root of the nerve of either side dorsally into the fasciculus longitudinalis dorsalis.

The abducens, having issued from the medulla oblongata, runs forward beneath the hypoarium and, in the sections both of Scorpaena and Lepidotrigla, turns downward over the anterior

edge of the cartilaginous proötic bridge and then runs backward beneath that bridge to enter and supply the rectus externus. In the adults both of Scorpaena and Trigla, the nerve perforates the bony proötic bridge to reach its muscle. In Cottus octodecimospinosus it runs over the anterior edge of the bony bridge. In small specimens of Dactylopterus it enters the trigemino-facialis chamber through the facialis foramen, and traversing that chamber ventral to all the other nervous structures issues by the trigeminus opening of the chamber and then immediately enters its muscle.

TRIGEMINO-FACIALIS COMPLEX.

This complex has, in Scorpaena, five apparent roots, as Stannius has stated that it has in Trigla, but two of these roots, the lateralis roots, may issue as a single root from the medulla and then immediately separate. These two lateralis roots and the motor facialis root are so closely applied, at their origin, that they appear almost as a single root, and are so shown in figure 28. In that figure, furthermore, the communis root appears crowded down between the trigeminus and the lateralis and motor facialis roots, this not being its position in sections of young specimens.

My sections did not permit of more than a very general determination of the central origin and peripheral distribution of the fibers of the several roots, but comparison with Menidia will show that these determinations are probably correct.

a. Roots and Ganglia of the Complex.

The anterior one of the five roots of the complex is the so-called root of the trigeminus, and it contains both motor and general cutaneous fibers. The motor fibers lie on the dorso-mesial aspect of the root as it emerges from the medulla. The fibers of the deep sensory root lie lateral to these motor fibres, the two bundles of fibers extending dorso-mesially into the medulla, lying close together, and certainly having their principal origins in groups of cells that represent respectively the chief sensory and motor nuclei of the trigeminus. The remaining, ventral fibers of the root enter the spinal V tract. The motor fibers, having issued from the medulla, soon cross, as in Menidia, to the ventral surface of the root, and so continue during their intracranial course. The entire root, running forward and laterally, lies at first, in sections, mesial to the other roots of the complex and then between the lateralis trigemini and lateralis facialis roots, ventral to the former and dorsal to the latter. While still in the cranial cavity it gives off the profundus root. It then traverses the trigeminus foramen, enters the trigemino-facialis chamber, and there immediately swells into the large trigeminus ganglion, which, in my young specimens, seems wholly distinct and separate from any other portion of the ganglionic complex excepting only the large related sympathetic ganglion. The ganglion lies almost wholly in the trigemino-facialis chamber, a small collection, only, of cells being found on the ventral surface of the root just before it issues through its foramen; these cells being connected with the main ganglion by a small ganglionic strand which traverses the foramen. The ganglion thus lies almost entirely in the cranial wall and not in the cranial cavity, all the other ganglia of the complex, excepting only the related sympathetic ganglion, lying in the cranial cavity itself.

The profundus root arises from the sensory portion of the trigeminus root, on its antero-mesial aspect, and running antero-laterally enters the intracranial profundus ganglion which lies slightly antero-mesial to the large stalk formed by the other roots of the complex.

The next posterior root of the complex is the motor root of the facialis. This root emerges from the medulla close to the anterior root of the nervus acusticus, almost as a part of that root,

and directly anterior to the low swelling of the acusticus part of the tuberculum acusticum; the anterior root of the acusticus spreading, and entering the medulla both dorsal and ventral to the level of the point of exit of the motor root of the facialis. After the root emerges from the medulla it lies dorso-anterior to the anterior root of the acusticus, between it and the overlying lateralis facialis root, but it soon passes up along the lateral surface of the latter root and reaches its dorsal surface. There it continues forward closely applied to the lateralis facialis and issues, with that nerve, through the facialis foramen. As the two nerves pass through the foramen, of shortly before, they receive a large bundle of fibers from the communis ganglion, the three components together forming the truncus facialis. This truncus does not traverse the trigeminus ganglion, passing postero-ventral to that ganglion. As in Menidia, it contains no general cutaneous component.

The next posterior root is the communis root. This root leaves the medulla almost directly dorsal to the motor facialis root, its point of origin lying immediately dorsal to the low, acusticus swelling of the tuberculum acusticum, and immediately anterior to the low, lateralis swelling of the same structure. Immediately after issuing from the medulla it lies wedged in between the lateralis trigemini and lateralis facialis roots, and, anterior to that point, lies lateral and then ventral to the trigeminus root as that root passes between the two lateralis roots. It then swells into a large pear-shaped intracranial ganglion, the large end of the pear directed antero-laterally, and the ganglion occupying the ventral or ventro-mesial portion of the large root-stalk of the complex. From the anterior portion of this ganglion, three bundles, or groups of sub-bundles of fibers arise, their arrangement being somewhat different on the two sides of the one specimen in which they were traced. One of these bundles is the ramus palatinus facialis which runs downward in the cranial cavity and, perforating the base of the proötic bridge, enters the myodome. A second one of the three bundles is a group of sub-bundles which traverses the trigeminus foramen; containing two separate sub-bundles on one side of the specimen and three on the other. One of these sub-bundles enters and traverses the trigeminus ganglion, going mainly if not entirely to the ramus oticus; the other one or two sub-bundles traversing the ganglion to enter the truncus maxillo-mandibularis trigemini. The third bundle that arises from the main ganglion traverses the facialis foramen and it was single on one side of my specimen but double on the other. On the single side the entire bundle entered the truncus facialis, a small branch being immediately sent to Jacobson's anastomosis. On the double side, one of the two sub-bundles went to the truncus facialis and Jacobson's anastomosis, the other sub-bundle running upward in the trigemino-facialis chamber and entering the truncus maxillo-mandibularis. This latter arrangement was also found on one side of the adult specimen used for figure 28, and hence is probably not unusual.

The communis root of Scorpaena thus differs from that of Menidia only in that two separate bundles of fibers, instead of a single one, go to the truncus maxillo-mandibularis. Whether both bundles go to the ramus maxillaris, or one to that ramus and the other to the ramus mandibularis, I could not determine. Scorpaena further differs from Menidia in the absence of any intracranial recurrent communis nerves, and Trigla, Lepidotrigla and Dactylopterus all agree with Scorpaena in this respect. In Cottus, on the contrary, there is an important intracranial recurrent branch.

The next two roots of the complex, in Scorpaena, the two that have the most posterior apparent origin from the medulla, are the roots of the lateralis trigemini and lateralis facialis nerves. These two roots arise as a single root from the tuberculum acusticum immediately posterior to the communis root and immediately dorso-posterior to the anterior root of the acusticus, between that root and

the posterior root of the same nerve. Running forward, and soon separating, each root swells slightly into an elongated intracranial ganglion, from which the lateralis trigemini and lateralis facialis nerves respectively arise.

In the other fishes of the group the roots and ganglia of the complex conform closely to those in Scorpaena, excepting only in the number and arrangement of the bundles of fibers that arise from the communis ganglion. In the one specimen of Lepidotrigla that was examined, all of these latter fibers arose from the ganglion as a single bundle which immediately separated into two parts, both of which traversed the facialis foramen and entered the trigemino-facialis chamber. One of these two parts is the palatinus facialis which turns forward in the trigemino-facialis chamber and issues through the trigeminus opening of that chamber. The other part separates into two bundles as soon as it enters the chamber, one of these bundles joining the trigeminus nerves and containing all the communis fibers destined to those nerves, while the other bundle contains the fibers destined to Jacobson's anastomosis and the truncus hyoideo-mandibularis facialis. In Dactylopterus one bundle of fibers traverses the trigeminus foramen, and another the facialis foramen, the latter bundle separating into three parts, the facialis branch to Jacobson's anastomosis, the ramus palatinus and the communis component of the truncus hyoideo-mandibularis facialis.

The fact that all of the communis fibers destined to the nervus trigeminus issue from the cranial cavity, in Lepidotrigla, by the facialis foramen might be considered as evidence in favor of the assumption that the communis fibers of the V—VII complex of that fish all belong to the nervus facialis; but it must not be overlooked that the fibers destined to the trigeminus all issue from the trigemino-facialis chamber by the trigeminus opening of that chamber, the fibers that issue through the facialis opening of the chamber all going to the nervus facialis. It is also to be noted that on one side of the 55 mm Scorpaena, and also on one side of the adult Scorpaena used for figure 28, a condition is found that is intermediate to that found on the other side of those two specimens and to that found in Lepidotrigla. These differences in the course of these fibers would all be explained by the assumption that the entire trigemino-facialis ganglionic complex was, in the immediate ancestor or ancestors of all teleosts, enclosed in a trigemino-facialis chamber in the cranial wall, as it actually is in Amia, and that the perforations of the inner wall of this chamber are not necessarily of segmental importance. But while there is much in favor of these assumptions it is to be noted: that in the Plagiostomata, according to Stannius, ('49, p. 32), the ganglion of his third root of the trigemino-facialis complex is always extracranial, while the ganglion of his first root, is intracranial; and that in Petromyzon, according to Johnston ('05 b), the ganglion of the facialis has its general cutaneous and communis components intracapsular, but its lateralis components extracapsular in position; and that the descriptions lead one to conclude, although it is not definitely so stated, that the ganglion of the trigeminus is extracapsular.

b. Truncus Ciliaris Profundi.

The truncus ciliaris profundi is the only nerve that arises from the profundus ganglion. Running forward in the cranial cavity it usually issues, in Scorpaena, through a special foramen in the proötic, but in two instances it was found traversing the oculomotorius foramen with the oculomotorius. In Cottus, Trigla and Lepidotrigla, in all the specimens examined, it issued through a foramen that lies close to the trigeminus and facialis foramina, these two latter foramina lying, the former dorso-anterior to the latter and the profundus lying between and immediately anterior to them.

In small specimens of Dactylopterus the ciliaris profundi issues through the large trigeminus foramen.

According to Stannius ('49, p. 38), the ciliaris profundi of teleosts perforates the „Keilbeinflügel" (alisphenoid), but this certainly is not true of any of the mail-cheeked fishes I have examined, nor of Scomber, in all of which fishes it perforates the proötic.

In Cottus, Trigla and Lepidotrigla, as in Ophiodon (Allen, '05), the truncus ciliaris profundi is accompanied, in its passage through its foramen, by the encephalic branch of the jugular vein. In Dactylopterus and Scorpaena, that vein traverses the trigeminus foramen, associated with the truncus profundi in Dactylopterus, but not in Scorpaena.

In Scorpaena, the ciliaris profundi receives, immediately after issuing from the skull, a branch from the large sympathetic ganglion associated with the trigeminus, and then separates into its two parts, the ciliaris longus and the radix longa. The ciliaris longus is much the thicker nerve of the two, and running upward and forward, dorsal to the rectus externus and posterior and somewhat parallel to the rectus superior, pierces the eyeball between that muscle and the rectus externus. The radix longa continues onward near the nervus oculomotorius and soon enters the ciliary ganglion; this latter ganglion also receiving, on both sides of the adult specimen used for figure 28, an independent sympathetic strand coming from the trigeminus sympathetic ganglion. This latter strand was not evident in the sections. The ciliary ganglion is connected with the oculomotorius by the radix brevis, and from it a single nerve arises, the ciliaris brevis, which joins and accompanies the nervus opticus and pierces the eyeball not far from that nerve.

In Lepidotrigla the ciliaris profundi, after issuing from its foramen with the encephalic vein, turns downward and forward close against the outer surface of the cranial wall, closely accompanying the internal jugular vein and lying, with that vein, immediately beneath the anterior portion of the trigeminus sympathetic ganglion. From the latter ganglion it receives a strand, and then, joining and accompanying the nervus oculomotorius, separates into its two portions shortly before it reaches the ciliary ganglion. In both Cottus scorpius and Cottus octodecimospinosus, and also in Dactylopterus, strictly similar conditions are found.

The profundus ganglion and its root, and the ciliaris longus and radix longa, are all described by Stannius in Trigla gurnardus and Trigla hirundo, these two teleosts being the only ones in which that author found an independent profundus ganglion. Of Cottus (species not given) Stannius says ('49, p. 38), that the ramus ciliaris arises from the trigeminus ganglion, close to the ramus ophthalmicus trigemini; a statement certainly not true of either of the two species of Cottus that I have examined.

In Menidia, the radix ciliaris longa of Herrick's descriptions is simply the sympathetic strand sent from the trigeminus sympathetic ganglion to join the true radix longa, this latter radix being his ramus ophthalmicus profundus.

In Petromyzon, the root of the profundus is said by Johnston ('05 b, p. 186) to contain some lateralis fibers.

c. Nervus Trigeminus.

The several motor and general cutaneous branches of this nerve all have, in all the fishes of the group, their apparent origin from the trigeminus ganglion, that ganglion lying in the trigemino-facialis chamber.

The lateralis fibers destined to the rami buccalis and oticus enter the trigeminus ganglion as a single bundle, and while traversing the ganglion separate into two bundles, one destined to each of the two nerves. The fibers that go to the ramus ophthalmicus lateralis do not traverse the ganglion, lying, in sections, either wholly separate and immediately dorsal to the ganglion or partly embedded in its dorsal surface. This ophthalmicus bundle of lateralis fibers always traverses the skull either through a partly separate part of the trigeminus foramen or through a wholly separate but closely adjacent foramen.

From the trigeminus ganglion, in Scorpaena, the ramus ophthalmicus trigemini, the truncus maxillo-mandibularis trigemini, the ramus communicans ad truncus hyoideo-mandibularis facialis, and two independent branches arise; all of these branches issuing from the trigemino-facialis chamber by its trigeminus opening excepting only the ramus communicans ad nervus facialis, which latter nerve issues through the facialis opening of the chamber. Two or three bundles of communis fibers traverse the ganglionic mass, one or two bundles going to the truncus maxillo-mandibularis and the other one going toward the ramus ophthalmicus, but, so far as could be determined in my quite unsatisfactory sections, going wholly to a branch that accompanies the ramus oticus lateralis.

The ramus ophthalmicus trigemini arises from the anterior end of the trigeminus ganglion by two strands in all the sections of Scorpaena, Cottus and Lepidotrigla, one of these strands running forward dorsal and the other ventral to the ophthalmicus lateralis. From the dorsal one of the two strands, in Scorpaena and Lepidotrigla, a small branch, apparently a purely general cutaneous one, is soon sent through the alisphenoid with the lateralis branch that goes to the small sixth organ of the supraorbital canal, the two nerves being accompanied by a branch of the external carotid and also by a branch of the vessel x. The general cutaneous component of this small nerve would seem to be the homologue of one or both of the two meningeal nerves said by Herrick ('99, p. 205) to have an extracranial origin in Menidia; and it may be added that no intracranial meningeal nerves were evident in Scorpaena. Of these two nerves in Menidia, Herrick says, „I regard them as primarily general cutaneous nerves" but „doubtless accompanied by sympathetic or other visceral fibers." They are said to be „destined chiefly at least, for the skin of the top of the head", which would seem to exclude them largely from the meningeal category. In embryos of Cottus this small reëntrant branch of Scorpaena and Lepidotrigla was not traced.

After giving off this small reëntrant branch, the two ophthalmic nerves of Scorpaena and Lepidotrigla, accompanied by the ophthalmicus lateralis, run forward dorsal to all the nerves and muscles of the orbit, give off several branches while in the orbit, and then pass through the canal between the frontal, mesethmoid and ectethmoid to reach the dorsal surface of the snout; their further course not being investigated. In Ameiurus, Herrick ('01) says that the ramus ophthalmicus, his supraorbital trunk, contains communis as well as general cutaneous fibers, which seems certainly not true of the mail-cheeked fishes. According to Sagemehl ('84b, p. 71) the ramus ophthalmicus, in the Characinidae, perforates the ectethmoid by a special canal; which is also not true of any of the mail-cheeked fishes I have examined, nor of Scomber either.

The truncus maxillo-mandibularis separates, as usual, into maxillary and mandibular portions, the former being accompanied by the buccalis lateralis. A small branch is given off before the truncus separates into its two parts, and running upward and backward innervates first the levator arcus palatini and then the dilatator operculi. The further course and distribution of the nerve was not investigated.

The ramus communicans ad truncus hyoideo-mandibularis facialis, in Scorpaena and Lepidotrigla, is entirely of general cutaneous fibers, and running postero-laterally through the facialis opening of the trigemino-facialis chamber joins the truncus facialis immediately beyond the motor branches to the adductor arcus palatini and adductor hyomandibularis. In Cottus a corresponding branch is found, and it is doubtless a general cutaneous one though this could not be determined in my sections.

The two independent branches that arise from the trigeminus ganglion in Scorpaena, arise from its anterior end. One runs upward and laterally across the anterior edge of the levator arcus palatini, and is distributed to the skin along the hind margin of the orbit. The other branch apparently contains both general cutaneous and communis fibers, and as it joins and accompanies the oticus lateralis it will be described with that nerve. In Lepidotrigla the first one of these two branches is found, but there is apparently no branch joining the oticus lateralis.

In Dactylopterus two general cutaneous branches arise from the anterior end of the trigeminus ganglion. One of these branches joins and accompanies the ophthalmicus lateralis and is the ramus ophthalmicus trigemini. The other separates into two parts, one of which joins the oticus lateralis, the other traversing the alisphenoid by an independent foramen, accompanied by a blood vessel which is apparently the anterior cerebral vein of my descriptions, but not accompanied by lateralis fibers; the lateralis branch to the posterior supraorbital organ not perforating the alisphenoid in this fish and not having a partly intracranial course, as in the other fishes of the group. Dactylopterus differs also from the other three fishes examined in this connection, in that there are two instead of one communicating branches from the trigeminus ganglion to the nervus facialis, both of them containing general cutaneous fibers only. One of these branches arises from the posterior end of the ganglion, and passing backward through the facialis opening of the trigemino-facialis chamber joins the nervus facialis internal to the hyomandibular. The other branch arises further forward from the ganglion, passes outward through the trigeminus opening of the chamber and then runs postero-ventrally, external to the hyomandibular, to join the truncus mandibularis facialis after it issues from the facial canal in the hyomandibular. This condition in Dactylopterus is somewhat similar to that described by Herrick in Menidia, where there are also two communicating branches, one quite undoubtedly issuing through the facialis and the other through the trigeminus opening of a trigemino-facialis chamber, although this chamber is not described and the references to the related foramina are perplexing. But the two branches in Menidia differ from those in Dactylopterus in that they unite to form a single nerve which passes internal to the hyomandibular to join the truncus hyoideo-mandibularis, no portion of either of them joining the nerve external to that bone. Stannius says ('49, p. 47) that this communicating branch from the trigeminus to the facialis is found in nearly all teleosts, and that it issues from the skull with the truncus maxillaris trigemini; the latter part of the statement being an evident error as regards certain teleosts.

d. Nervus Facialis.

This nerve includes, according to the component theory, all the fibers that are contained in the lateralis and communis roots of the trigemino-facialis complex, as well as those of the motor facialis root.

The dorsal one of the two lateralis roots, which I have called the lateralis trigemini, separates, while still in the cranial cavity, into ophthalmicus and buccalis portions.

The ophthalmicus lateralis almost always, in the adult of Scorpaena, traverses a separate foramen which lies directly above the trigeminus foramen, and the nerve lies upon the dorsal surface

of and does not traverse the trigeminus ganglion. Immediately after issuing from the skull it gives off a small branch which turns upward and inward and, perforating the alisphenoid, enters the cranial cavity. There it runs upward along the inner surface of the skull, lying in the membranous tissue that lines that surface, and, piercing the frontal, reaches the small sixth organ of the supraorbital canal, which it innervates. It is accompanied by a delicate branch of the trigeminus, apparently of general cutaneous origin, as already stated, but this branch could not be separately traced in the cranial cavity. In Lepidotrigla the same mixed nerve is found. In Cottus scorpius a similar nerve is also found; but in the sections of this fish the nerve is lost beneath the terminal tube of the supraorbital canal, and no organ is evident in that tube. In the adult Cottus octodecimospinosus the nerve is found innervating the terminal organ of the supraorbital canal, as in Scorpaena and Lepidotrigla. Slightly posterior to this nerve, in Cottus, and having a closely parallel course, there is a communis nerve which has an intracranial origin from the communis ganglion, and from there runs upward and then backward along the side wall and roof of the cranial cavity. Whether or not this nerve anastomoses with an intracranial branch of the vagus could not be determined in Cottus scorpius, but in Cottus octodecimospinosus it does anastomose with such a branch and then issues near the hind end of the skull; this seeming to indicate that it must form the anastomosis in Cottus scorpius also. The nerve is accordingly the ramus lateralis trigemini of Stannius's descriptions, called by Herrick, in his descriptions of Menidia, the facialis root of the ramus lateralis accessorius. It is said by Stannius not to be found in Trigla, which I confirm. It is also not found in Scorpaena or Dactylopterus.

In the Cod, the facialis root of the lateralis accessorius is said by Herrick ('00) to be present and to be accompanied by a few coarse fibers from the lateral line ganglion, which fibers would accordingly seem to correspond to the branch to organ 6 supraorbital in Scorpaena. Whether or not this latter branch of Scorpaena is represented in Pleuronectes by any part of Cole & Johnstone's ('01, p. 128) ramus lateralis accessorius facialis, I can not decide. In Ameiurus it is represented in Herrick's ('01) branch N. 5, which has a wholly intracranial course until it pierces the frontal to reach its organ; a branch of the nerve going to the anterior head line of pit organs.

The ophthalmicus lateralis, in Scorpaena, having given off the branch to organ 6 supraorbital, runs forward between the two strands of the ophthalmicus trigemini and soon gives off a branch which, running upward, separates into two parts and supplies the fourth and fifth organs of the supraorbital canal. This branch, in the several specimens of Scorpaena examined, and as already stated, sometimes separated into its two parts before it pierced the frontal, sometimes so separated while in its canal in the frontal, and, in one specimen, entered the supraorbital canal as a single nerve which then, lying in the canal, supplied, first, organ No. 4 and then organ No. 5. After giving off this branch the ophthalmicus lateralis continues forward, sends branches in succession to the third and second supraorbital organs, and then supplies and terminates in the first organ of that line.

The ramus oticus, in Scorpaena, separates from the buccalis while that nerve is traversing the trigeminus ganglion, and issues from the ganglion as an independent lateralis branch but accompanied by two bundles of fibers one of which is of general cutaneous and the other of communis origin. This latter bundle issues from the cranial cavity through the trigeminus foramen, and, so far as my quite unsatisfactory sections show, contains all the communis fibers that go to the trigeminus excepting those that accompany the truncus maxillo-mandibularis. These three bundles of fibers, united to form a single nerve, run upward and laterally along the hind wall of the orbit and, traversing the

oticus canal in the sphenotic, issue on the dorsal surface of the skull beneath the frontal bone. A lateralis branch is then sent to the infraorbital organ in the postfrontal, and a second branch to the organ in the pterotic, these two branches apparently containing all the lateralis fibers of the nerve. The remainder of the nerve then runs backward beneath the dermal bones of the top of the skull, enters the temporal fossa and there runs into and anastomoses with the supratemporal branch of the vagus, branches being sent backward, from the united nerves, along the dorsal surface of the trunk. As the main nerve passes dorso-mesial to the dilatator groove, it lies very close to that groove, and may even be exposed in the bottom of it. A venous vessel, a branch of the external jugular, here perforates the bottom of the groove and joins the nerve, accompanying it in its further course toward the hind end of the skull.

In Lepidotrigla the ramus oticus is a purely lateralis nerve, and is not continued posteriorly beyond the second organ in the pterotic, the pterotic in this fish lodging two organs innervated by the oticus, without an intervening primary tube. This condition of these two organs in this fish would seem to represent a stage in the reduction of the two organs here found normally developed in Amia and certain other fishes to the one organ found in Scorpaena and still other fishes; a reduction strictly similar to that that is taking place in the 4 th. and 5 th. supraorbital organs both of Lepidotrigla and of Scorpaena. In Lepidotrigla, the general cutaneous and communis fibers that accompany the oticus in Scorpaena are represented (or replaced) by fibers that do not traverse the oticus canal; and this is also the condition in Amia, in which fish the ramus oticus is also a purely lateralis nerve while the ophthalmicus lateralis branch that supplies the anterior head line of pit organs is accompanied by fibers the character of which was not determined in my work on that fish, but which have an apparent origin and distribution similar to that of the fibers that accompany the oticus in Scorpaena.

In Dactylopterus the oticus lateralis is accompanied by a bundle of general cutaneous fibers, and apparently by those fibers only.

In Ameiurus, the ramus oticus is said by Herrick ('01) to contain lateralis, general cutaneous, and communis fibers, to have an intracranial origin, and, running upward, to pierce the roof of the skull; which would seem to mean that it does not first issue in the hind end of the orbit before entering and traversing the oticus canal. In Menidia the ramus oticus is said by Herrick ('99) to contain lateralis and general cutaneous fibers, and to correspond to the ramus oticus plus the external buccal of Cole's descriptions of Gadus: that is, its lateralis fibers innervate not only the latero-sensory organs in the postfrontal and pterotic sections of the main infraorbital canal but also the organ in the dorsal postorbital bone. The ramus oticus of Menidia, minus the external buccal portion, is said to traverse a canal in the sphenotic and, as just above stated, it contains both lateralis and general cutaneous fibers. This intimate association, in this nerve, of fibers that are considered by the author to have a central origin in the facialis and trigeminus segments, respectively, leads Herrick to conclude that the oticus „was probably originally the dorsal ramus of the facial nerve to which lateralis elements have been secondarily added and whose general cutaneous portion has, like that of the profundus nerve, been cenogenetically fused with the Gasserian ganglion". That is, it is assumed, in this statement, that general cutaneous fibers that originally issued from the brain by three distinctly different apparent roots, and that belonged to three distinctly different but adjacent metameric segments, have come, in Menidia, to issue by a single apparent root and from a single, unsegmented cerebral center; this being the result of a central condensation so complete that all traces of the ori-

ginal subdivisions of the root and center have been lost. The equally evident assumption that all the lateralis fibers associated with trigeminus nerves are trigeminus ones cenogenetically fused with the lateralis fibers of the facialis segment, is not made; and yet this assumption has apparently much more evidence in fact, for the lateralis trigemini and lateralis facialis fibers here, and in many other fishes also, arise by separate apparent roots and each have an independent ganglion. Johnston, in a recent work ('05 a, p. 222), does make what is practically the equivalent of this assumption, for he there says that it seems probable to him that the supraorbital, infraorbital and hyomandibular latero-sensory lines belong respectively to the profundus, trigeminus and facialis segments. He does not, however, say that the nerves innervating the three lines must also belong to those same segments, and such may not be his meaning.

One other point relating to this same subject can here be mentioned. In many teleosts, as already stated, a strand of general cutaneous fibers, arising from the Gasserian ganglion, joins the truncus hyoideo-mandibularis facialis. These fibers join that nerve extracranially in Scorpaena, Menidia and many other fishes, but intracranially in Pleuronectes (Cole & Johnstone, '01, p. 124). Here then is another instance in which the cenogenetic fusion of fibers belonging originally to the trigeminus and facialis segments might be suggested, but neither Herrick nor Johnston ('05 a) even intimate it; and yet, in Amia, Kingsbury ('97), before the publication of Herrick's work, had stated that general cutaneous fibers issue from the brain in the root of the facialis in all the specimens of that fish that he had examined, and Johnston ('05 b), since the publication of Herrick's work, says that they also issue in that root in Petromyzon.

And if the assumption of cenogenetic fusions can be made either for the general cutaneous or lateralis fibers of the complex, why can it not also be made for the communis fibers? Those fibers then would, in large part at least, normally belong to the nerves with which they are associated, certain juxtapositions perhaps being possible where there are no skeletal elements to prevent them; and the varying quantity of communis fibers in the several trigeminus and facialis nerves would be due to a corresponding variation in the development of the terminal organs innervated by either nerve.

Returning now to the descriptions, the buccalis facialis traverses, in all the fishes examined, the trigeminus ganglion, and, accompanying the ramus maxillaris trigemini, supplies the organs of the post- and sub-orbital portions of the main infraorbital canal.

The truncus facialis, in Scorpaena, Lepidotrigla and Dactylopterus contains motor, lateralis and communis fibers, the latter fibers, in all these fishes, traversing the facialis foramen and joining the other fibers of the truncus either as they are traversing, or after they have traversed the same foramen.

The ramus palatinus contains communis fibers only, and in Scorpaena it usually has an independent origin from the communis ganglion. In the 55 mm Scorpaena, it had such an origin on one side of the head, while on the other side it arose from the base of the bundle of communis fibers sent to the trigeminus ganglion. Turning downward in the cranial cavity, the nerve traverses the palatine canal in the proötic, enters the myodome, and, turning forward, enters the orbit along its floor; its further course not being traced. In Cottus, the palatinus has a course similar to that in Scorpaena, but in Trigla, Lepidotrigla and Dactylopterus it does not separate from the other communis fibers until after those fibers have traversed the facialis foramen. There it turns forward and downward along the floor of the trigemino-facialis chamber, issues through the trigeminus opening of that chamber, and, traversing the myodome of the fish, enters the orbit.

The next branch of the truncus facialis, in the 55 mm Scorpaena, is given off as the truncus traverses its foramen, and contains communis fibers only. Turning downward and backward it issues through the facialis opening of the trigemino-facialis chamber and then almost immediately joins and anastomoses completely with the ramus anterior of the nervus glossopharyngeus. The nerve so formed is Jacobson's nerve. It runs antero-ventrally along the dorso-anterior aspect of that part of the hyoid cleft that lodges the opercular hemibranch, and is distributed to that hemibranch and to the adjacent tissues on the anterior surface of the cleft, delicate branches of the nerve accompanying both the efferent and afferent arteries of the hemibranch. In both Cottus and Lepidotrigla this nerve is found in almost identical conditions, and it doubtless also is in Dactylopterus, but in this latter fish it was not traced beyond the point of its anastomosis with the glossopharyngeus. The fibers of the glossopharyngeus all run distally with the facialis fibers, none of them turning proximally along the facialis nerve, as I was led to suppose might be the case in Scomber.

Immediately before or after the facialis branch to Jacobson's nerve arises from the truncus facialis, that truncus receives, in both Scorpaena and Lepidotrigla, a communicating branch or branches from the facialis sympathetic ganglion, this connection doubtless existing also in the other fishes of the group but not there being traced.

After giving off the nerve to Jacobson's anastomosis, the facialis, in Scorpaena and Lepidotrigla, sends a motor branch to the adductor arcus palatini, and then a branch to the adductor hyomandibularis; this latter branch also innervating the adductor and levator operculi. These two nerves together form the ramus opercularis profundus of Herrick's nomenclature. The branch that goes to the adductor hyomandibularis is joined posteriorly by and anastomoses with a branch of the supratemporal branch of the nervus vagus, certain of the fibers of the vagus running proximally along the fibers of the opercularis profundus and the two nerves thus appearing as a complete and uninterrupted circuit. In Cottus and Dactylopterus the opercularis profundus is also found, but its anastomosis with a branch of the vagus was not traced.

The truncus facialis, in Scorpaena and Lepidotrigla, is then joined by the communicating branch from the trigeminus ganglion and becomes the truncus hyoideo-mandibularis of Stannius' nomenclature. This nerve continues laterally and slightly downward and enters the facialis canal in the hyomandibular, lying, in its course, postero-dorsal to the adductor arcus palatini and anterior to the adductor hyomandibularis and to all of the levator muscles of the branchial arches. As it enters its canal in the hyomandibular, a branch is sent backward in the small branch canal in the hyomandibular, and, separating into two parts, innervates the two dorsal latero-sensory organs in the preopercular canal. This small branch is the ramus opercularis superficialis of Herrick's nomenclature, and it was traced in the dissections and not in the sections of Scorpaena; the sections here being quite imperfect. In the dissections no branch could be found distributed to the outer surface of the operculum, such as Herrick describes in Menidia, but in Lepidotrigla this branch was found, though the character of its fibers could not be determined. In Menidia these fibers of the nerve are said by Herrick to be partly general cutaneous and partly lateralis. These latter fibers are said to supply certain naked cutaneous sense organs lying on the outer surface of the operculum, these organs being of that intermediate type between pit-organs and terminal buds which are always puzzling to every observer. Herrick concludes that these organs must, because of their innervation, belong to the lateral line rather than the communis system, a conclusion I am not prepared, from the facts so far presented, to accept. In the Cod the corresponding fibers of this nerve are said by Herrick ('00) to probably be wholly

lateralis ones, and they are said to have been definitely traced to certain opercular pit organs. In Pleuronectes, Cole and Johnstone ('01, p. 132) also find the nerve a purely lateralis one, its terminal branches supplying an opercular line of pit organs.

Having given off this small branch the main truncus, in Scorpaena and Lepidotrigla, traverses the facialis canal in the hyomandibular and issues on the external surface of the shank of that bone. There it separates into its two parts, the ramus hyoideus and truncus mandibularis, the latter of which soon separates into the rami mandibularis externus and internus. The ramus hyoideus runs downward and backward through the opening between the hyomandibular and the preopercular and so reaches the hyoid arch, its further course not being traced. The rami mandibularis externus and internus run downward and forward across the hyomandibulo-symplectic interspace of cartilage, and then pass, respectively, through the openings on the posterior and anterior side of the symplectic, as already fully described, and so reach the inner surface of the palato-quadrate apparatus and then the mandible. The externus sends branches, as usual, to the latero-sensory organs of the preoperculo-mandibular line, and certain branches also to the general tissues, the nerve thus not being a simple latero-sensory nerve. The internus goes to the inner surface of the mandible, its special distribution and relations to the other nerves not being investigated. Whether it contains communis fibers, and those fibers only, as in Menidia, could not be determined, but, whatever its composition may be, it is a true ramus mandibularis internus as that nerve is defined by Stannius. Herrick ('99, p. 171) takes the position, and it may be correct, that a nerve can not be a mandibularis internus unless it contains communis fibers; and the inference is that it must contain those fibers alone, for he says that the nerve is absent in Gadus notwithstanding that both Stannius and Cole describe a nerve in that fish that is said to have the topographical position of an internus. Neither Stannius' nor Cole's descriptions of the course of the nerve being very definite, I have had the nerve looked for in dissections of Gadus merlangus, but it could not be found; which would seem to confirm Herrick's conclusion that the nerve, when present, contains communis fibers only.

In Dactylopterus the truncus hyoideo-mandibularis facialis does not traverse a single canal in the hyomandibular and issue on the external surface of that bone, as it does in Scorpaena, Cottus, Trigla and Lepidotrigla. When it reaches the internal surface of the hyomandibular the nerve, in Dactylopterus, separates into its two portions, the ramus hyoideus and the truncus mandibularis, the latter of which alone traverses the facialis canal through the bone and issues on its external surface. The ramus hyoideus simply passes beneath a bridge of bone on the internal surface of the hyomandibular and reappears on the internal surface of that bone. This will be further discussed when describing the bones in this fish. From the truncus mandibularis, as it enters its canal in the hyomandibular, a lateralis branch, accompanied by what are apparently wholly general cutaneous fibers, passes backward through a small branch canal in the bone, this nerve supplying the two dorsal organs of the preopercular canal and the tissues on the outer surface of the opercular. The truncus mandibularis contains communis fibers and is joined, after it reaches the outer surface of the hyomandibular, and as already stated, by the communicating general cutaneous branch that issues through the trigeminus opening of the trigemino-facialis chamber. After being joined by this communicating branch, the entire truncus mandibularis passes to the internal surface of the palato-quadrate through an opening that lies posterior to the symplectic, no evident branch passing inward anterior to that bone. There is thus no evident ramus mandibularis internus in this fish. The mandibularis externus, after it reaches the internal surface of the palato-quadrate, certainly con-

tains fibers other than lateralis ones, but whether they are all general cutaneous ones, or partly communis, could not be determined. If they are all general cutaneous ones, Dactylopterus would resemble Ameiurus (Herrick, '01) in this respect, the communis fibers that form part of the ramus mandibularis facialis in that fish all being distributed to regions external to the palato-quadrate.

NERVUS ACUSTICUS.

The nervus acusticus has, in sections of Scorpaena and Lepidotrigla, two roots, which enter the tuberculum acusticum close together, the slight swelling at their point of entrance lying immediately ventral to the swelling for the lateralis nerves. The anterior root belongs to the anterior division of the nervus, the posterior root to its posterior division.

The anterior division, or ramus vestibularis, running forward sends, in my 55 mm Scorpaena, two branches to the macula acustica sacculi. In the 63 mm Lepidotrigla, one of the two branches that go to this organ has a separate origin from the medulla, between the anterior and posterior roots of the nervus, the second branch arising from the posterior root. In both fishes, the ramus vestibularis then sends a branch to the macula acustica utriculi, another branch to the crista acustica in the ampulla of the external canal, and then ends in the crista acustica of the ampulla of the anterior canal. All of these several branches separate distally into two parts, the two parts of the two nerves that go to the ampullae supplying two separate and distinct organs in each of the ampullae, but the nerve that goes to the utriculus supplying different parts, only, of the large and continuous utricular macula.

The posterior division of the nervus, or ramus cochlearis, runs backward and separates into two parts one of which passes dorsal to the root of the glossopharyngeus and the other ventral to that root. The dorsal branch supplies the two organs of the crista acustica in the ampulla of the posterior canal, the ventral one supplying the two organs of the macula neglecta and also the papilla acustica lagenae. The lagena is partially differentiated as a diverticulum arising from the dorsal surface of the hind end of the sacculus.

The papilla lagenae and the maculae sacculi and utriculi each have related otoliths.

There was no indication of a ductus endolymphaticus in the dissections of Scorpaena, but in sections, both of embryos and of the adult, a small remnant of the ductus is evident. In Trigla hirundo the ductus is two or three times as large as in Scorpaena, being evident even in dissections. Retzius ('81) shows the ductus in Trigla gurnardus.

NERVUS GLOSSOPHARYNGEUS.

The nervus glossopharyngeus of Scorpaena arises by a single apparent root, composed, as in Menidia, of two bundles of fibers, a motor and a communis one.

After issuing from the medulla the root runs at first posteriorly, then turns outward between the dorsal and ventral branches of the ramus cochlearis acustici, and then forward and laterally to its foramen, passing between the sacculus and the sinus utriculi posterior. At the bend in the root there is an important collection of ganglion cells lying on the posterior aspect of the nerve, and from this ganglion, in the adult, an intracranial communicating branch was found, going to the root of the vagus. In the 55 mm specimen this branch could not be satisfactorily traced. In the 63 mm Lepidotrigla two branches arise from the ganglion, one of which joins the root of the vagus, the other one entering the intracranial vagus ganglion. The dorsal one of the two branches receives, on one side of

the specimen, but not on the other, a relatively important branch from the dorsal branch of the ramus cochlearis acustici.

Having traversed its foramen the nerve turns forward along the outer surface of the skull and swells into an elongated ganglion, which has a sympathetic ganglion associated with it. From this ganglion two nerves arise. One of these nerves is the ramus anterior of the nervus, which, running forward, anastomoses with the communis branch from the facialis to form Jacobson's nerve, as already described. The other branch is the ramus posterior of the nervus and was not further traced.

NERVUS VAGUS.

a. Nervus lineae lateralis vagi.

The root of the nervus lineae lateralis vagi issues from the tuberculum acusticum directly dorsal and slightly posterior to the root of the glossopharyngeus. In the 63 mm Lepidotrigla it arises by two roots, a small anterior and a large posterior one. It runs posteriorly in the cranial cavity and issues through the vagus foramen, there lying directly upon the dorsal surface of the root of the vagus. A supratemporal branch is immediately given off, and running upward innervates the latero-sensory organs of the supratemporal commissure and also those of the extrascapular and suprascapular sections of the main infraorbital canal; this branch having a separate extracranial ganglion. The main nerve then enters its own ganglion, and was not further traced. No ganglion cells are found in the main nerve before it issues from the cranial cavity, and there is no branch of the nerve accompanying the nervus glossopharyngeus.

b. Nervus Vagus.

The roots of this nerve could only be properly traced in the 63 mm Lepidotrigla. In this fish, and also in the small specimens of Scorpaena and Dactylopterus, three small rootlets arise from the medulla anterior to the main root of the nervus. These rootlets, in Lepidotrigla, arise one anterior to the other, in the line of the main root, at intervals of about 80 μ. They pierce what is apparently a two layered cranial membrane, richly supplied with blood vessels, the anterior rootlet then joining the main vagus root, while the other two traverse the intracranial vagus ganglion, as will be later described. The anterior rootlet seems to be a purely motor one, the other two apparently containing communis fibers only; but of these determinations I am not at all certain.

The main root of the nervus contains motor, communis and general cutaneous fibers, most of these latter fibers arising from the spinal V tract while some seem to have a superficial origin, coming down from above. The three bundles issue from the medulla, in Lepidotrigla, close together, as a single large stalk which is joined by the anterior one of the three anterior rootlets, and also by one of the two communicating branches from the intracranial ganglion at the bend in the root of the glossopharyngeus. On or in connection with the general cutaneous portion of the root, an important intracranial ganglion is formed, and this ganglion is joined by one of the branches from the glossopharyngeus and is traversed by two of the anterior rootlets of the vagus itself. From the ganglion a stout intracranial branch is sent upward in the cranial cavity and issues on the dorsal surface of the skull near its hind end, this nerve apparently receiving all its fibers from the two anterior rootlets of the vagus, and the nerve accordingly quite probably being largely if not entirely of communis origin. In the sections of Lepidotrigla it could not be determined whether or not this nerve anastomosed with the recurrent component that accompanies that branch of the lateralis facialis that innervates

organ 6 supraorbital; but in dissections of Trigla hirundo, where this intracranial branch is also found, the anastomosis of the nerve with the branch of the facialis was readily established. Stannius ('49, p. 85) says that this anastomosis is not found in Trigla gurnardus, and he also says that, in that fish, the nerve arises partly from the root of the nervus lineae lateralis. This last statement is certainly an error.

In Scorpaena no intracranial branch of the vagus could be found either in the sections or in the adult.

The main root, in Lepidotrigla, traverses the vagus foramen, there being distinctly separable into two bundles, one of which contains the motor and communis fibers, and perhaps also certain of the general cutaneous fibers, while the other arises directly from the intracranial ganglion and must be largely, if not entirely, composed of general cutaneous fibers. This latter bundle immediately turns upward, accompanying the supratemporal branch of the nervus lineae lateralis; but it soon leaves that nerve, and turning laterally and forward passes onto the external surface of the levator and adductor operculi muscles and is there in large part distributed to the inner and outer surfaces of the operculum, one branch of it, however, joining and anastomosing with the terminal fibers of the ramus opercularis profundus facialis. Whether any fibers of this nerve accompany the supratemporalis lateralis, or not, could not be positively determined, but none of them seemed to.

The remaining fibers of the root of the vagus soon swell into the large ganglionic mass of that nerve and were not further investigated.

OCCIPITAL NERVES.

The occipital nerves were not carefully traced, none of the series of sections prepared extending far enough to permit it. They are shown in figure 28 as found in the adult Scorpaena. They unite to form a single trunk which issues through the foramen in the exoccipital.

NERVUS SYMPATHETICUS.

A large sympathetic ganglion, the anterior cerebral sympathetic ganglion, lies in the trigemino-facialis chamber. Anteriorly this ganglion lies immediately ventral to, and is in contact with, the anterior portion of the trigeminus ganglion, but posteriorly it is separated from that ganglion by the jugular vein, the two ganglia being connected by several bundles of fibers. From the anterior end of the ganglion a branch is always sent to join the radix longa of the ciliary ganglion, and, in the one adult specimen of Scorpaena that was examined, a second branch is sent direct to the ciliary ganglion, as already fully described.

A second sympathetic ganglion lies ventral to the truncus facialis and is connected with that truncus by one or two strands; this ganglion sometimes being an independent ganglion and sometimes simply an enlargement of a posterior prolongation of the anterior ganglion. From the hind end of this second ganglion, the sympathetic trunk runs posteriorly along the side wall of the skull and swells into a ganglion beneath the glossopharyngeus ganglion, and then into another beneath the vagus ganglion; these sympathetic ganglia both being connected by fibers with the related ganglia of the cranial nerves.

II. Sebastes dactylopterus.

The skull of Sebastes dactylopterus is relatively taller and shorter than that of Scorpaena scrofa; the orbits being relatively larger, the interorbital region narrower, the antorbital region shorter, and the mid-dorsal line considerably more convex than in the latter fish. The space between the eyes is concave.

The ventral surface of the skull, starting immediately posterior to the dentigerous ridge on the ventral surface of the anterior end of the vomer, is slightly convex, the summit of the convexity lying beneath the foot of the basisphenoid.

The internasal ridge is similar to that in Scorpaena, but the mesethmoid processes are smaller and project almost directly forward instead of forward and upward. The bases of these processes are connected by a curved transverse ridge, concave anteriorly, against the anterior surface of which the hind end of the internasal ridge abuts and ends. Against the wide and slightly concave lateral surface of each process the corresponding nasal rests, that bone being firmly bound to the process and bearing, on the dorsal surface of its hind end, the nasal spine.

Immediately lateral to the base of the mesethmoid process, there is a large aperture which lies between the ectethmoid below and the anterior end of the frontal above. This aperture is the anterior opening of that section of the supraorbital latero-sensory canal that lies in the frontal, combined with the anterior opening of a small canal, between the ectethmoid and the frontal, that transmits the rami ophthalmicus lateralis and ophthalmicus trigemini. Starting from this aperture, a large rounded ridge runs backward between the orbits, curving at first slightly toward the middle line and then diverging slightly from it, and marking the course of the supraorbital latero-sensory canal. Beginning slightly posterior to its anterior end, the ridge bears on its dorsal surface a narrow ridge that runs posteriorly, concentric with the dorsal edge of the orbit, and, gradually increasing in height, terminates in a spine. This spine lies posterior to the transverse commissure formed by the fusion, in the middle line, of the fourth primary tubes of the supraorbital canals of opposite sides, and overhangs the seventh or terminal tube of the supraorbital canal. It is accordingly the frontal spine of the fish, and the narrow ridge that terminates in it is the frontal spinous ridge. The third primary tube of the supraorbital canal opens on the dorsal surface of the frontal, lateral to this frontal ridge, at about the middle point of the orbit.

The hind border of the supraorbital commissure is marked by a slight ledge, that part of the dorsal surface of the skull that lies posterior to the ledge lying at a slightly deeper level than the part that lies anterior to it. The frontal spinous ridge, curving postero-laterally, crosses the lateral end of the transverse ledge, and at this point, or from the mesial surface of the frontal ridge slightly posterior to it, the parietal spinous ridge begins. Running backward and slightly laterally from there, the parietal ridge terminates in the parietal spine, that spine lying directly above the supratemporal cross-commissural canal. The anterior end of the parietal ridge lies on the hind edge of the frontal, the remaining and larger part of it lying on the parieto-extrascapular. Immediately posterior to the parietal spine, a short ridge begins on the dorsal surface of the extrascapular part of the parieto-extrascapular, and, continuing the line of the parietal ridge, terminates, at the hind end of the skull, in the nuchal spine.

The nasal, frontal, parietal and nuchal spines of Sebastes thus form a row of spines on the dorsal surface of the skull that is strictly comparable to the middle row of spines in Scorpaena, but, as will

be explained below, the frontal spine has been displaced laterally to such an extent that it might be mistaken for one of the lateral row of spines.

The parietal spinous ridge and the transverse commissural ledge bound laterally and anteriorly a flat smooth median portion of the dorsal surface of the brain case, this surface lying at a slightly lower level than the anterior part of the dorsal surface of the skull. This flat and slightly depressed surface thus certainly represents a slightly developed subquadrangular groove on the vertex of the skull of the fish, notwithstanding that Günther ('60, vol. 2, p. 95) says that all members of this family are without that groove. Posteriorly, this slightly developed groove is bounded by a slight transverse ridge which lies on the dorsal surface of the parieto-extrascapular of either side, near its hind edge. This ridge extends to the mesial edge of either parieto-extrascapular, but as these bones do not meet in the middle line, the ridge does not extend entirely across the hind edge of the skull. The ridge marks the course of a portion of the supratemporal commissure, the median portion of that commissure lying in the dermal tissues, between the ridges of opposite sides, in a slight groove on the flat dorsal surface of the supraoccipital. The slightly depressed surface that represents the subquadrangular groove is thus not bounded posteriorly by a complete ridge, as in Scorpaena, simply because the median portion of the supratemporal commissure is not here enclosed in bone.

The lateral row of spines is represented by five spines. The anterior spine of the row is the preocular spine, lying on that edge of the ectethmoid that forms the anterior portion of the roof of the orbit. The next two spines of the row are the supraocular and postocular ones, both of which lie close together, one directly behind the other, on the dorsal surface of the roof of the orbit, near its lateral edge, and immediately anterior to the frontal spine. In the specimen used for illustration the postocular spine is bifid on one side of the head, and, anterior to the supraocular spine, there is a small additional spine. The supraocular and postocular spines, as normally found, together with the frontal spine form a short line of three spines lying close together and equidistant one from the other, and they correspond in position to the supraocular, postocular and tympanic spines of Jordan & Gilbert's diagram of the spines in Sebastodes. The frontal spine however belongs, as just above described, to the middle row of spines and not to the lateral one. The remaining two spines of the lateral row are small ones that hardly rise above the outer surface of the body, one of them lying on the hind edge of the suprascapular and the other on the hind edge of the supraclavicular. On the pterotic there is a ridge, but it does not end in a spine.

The intermediate row of spines is represented by a small spine on the hind edge of the epiotic process of the suprascapular, this spine lying slightly mesial to the suprascapular spine of the lateral row.

The bones of the snout of Sebastes differ in no important respect from those of Scorpaena scrofa. The mesethmoid processes, as already stated, are shorter than in Scorpaena, and are directed forward instead of upward and forward. The nasals are traversed by the supraorbital latero-sensory canal, and are relatively larger than in Scorpaena. The lateral arm of the ectethmoid is not differentiated from the wing of the bone, as it is in Scorpaena, the ventral edge of the wing being simply thickened and giving articulation, by two articular surfaces, to the lachrymal and palatine. The vomer has, on either side, an ascending process, which gives articulation, as in Scorpaena, by the intermediation of a disk of semi-cartilaginous tissue, to the ascending process of the maxillary. The maxillary has a right-angled ascending process and a ligamentary process, the former articulating both with the premaxillary and the vomer, and the latter giving support to the lachrymal and palatine, as in Scorpaena. The rostral is more deeply grooved on its ventral surface than in Scorpaena.

There are naso-maxillary, ethmo-maxillary, intermaxillary, rostro-palatine, rostro-nasal, rostro-maxillary, vomero-palatine, lachrymo-palatine and maxillo-mandibular ligaments, as in Scorpaena. And, in addition to these ligaments, there were, in the large specimen of Sebastes that was particularly examined, other well-developed ligamentous or fibrous bands that were not evident in the fibrous and connective tissue that, in the smaller specimens of Scorpaena that were examined, connected the several bones. One of these fibrous bands extended from the dorso-anterior edge of the ascending process of the maxillary to the mesial surface of the maxillary process of the palatine; and, lying on the dorsal surface of this wide band, a flat ligament extended from the same point to the anterior edge of the lachrymal. Another ligament extended from the proximal end of the shank of the maxillary into the angle between the ascending and maxillary processes of the premaxillary, binding these two bones together in the region of their articular surfaces. The naso-maxillary ligament, in this fish, spreads at its anterior end, and is there inserted partly on the anterior edge of the lachrymal as well as on the ligamentary process of the maxillary.

The frontal has a ventral flange as in Scorpaena.

The alisphenoid has slight ridges on its outer surface which represent those two little processes of the bone of Scorpaena that form, in that fish, ossified portions of the parasphenoid leg of the bone. The bone is traversed by a canal which transmits the nerve that innervates the terminal or sixth organ of the supraorbital canal, this canal beginning on the outer surface of the skull in the sutural line between the alisphenoid and proötic, and from there running upward in the alisphenoid to about the middle point of the bone, where it opens into the cranial cavity.

The trigemino-facialis chamber and related nerves are as in Scorpaena. On the outer surface of the proötic, immediately ventral to the trigemino-facialis chamber, the dorsal end of the first infrapharyngobranchial is strongly attached by fibrous tissues. The pedicle of the basisphenoid is straight, instead of being strongly curved. The myodome has proötic and basioccipital portions, and opens posteriorly onto the ventral surface of the basioccipital. The sphenotic is perforated, from its orbital face, by the oticus canal, this canal crossing the mesial end of the dilatator fossa and transmitting the oticus lateralis accompanied by a more slender nerve which runs backward into the temporal fossa. The dilatator fossa is relatively larger than in Scorpaena, but has no appreciable roof excepting along its anterior edge where it is roofed by the small postfrontal bone.

The dorsal surface of the pterotic is deeply excavated by the main infraorbital canal, the section of canal that is related to it being roofed only by a single narrow and delicate bridge of bone. Anterior to this bridge, and lying partly on the sphenotic and partly on the frontal, there is a large groove which lodges those portions of the main infraorbital and supraorbital canals that adjoin their point of anastomosis. Posterior to the pterotic bridge, between it and the anterior edge of the lateral extrascapular, there is a smaller, but still relatively large opening which is the latero-sensory opening between the pterotic and lateral extrascapular. The narrow pterotic bridge, and the narrow pterotic edges of the large groove that lodges the main infraorbital canal represent all there is of the outer, dorsal surface of the dermo-pterotic.

The lateral extrascapular is a delicate bone that covers a part only of the temporal fossa. It is traversed by the main infraorbital and supratemporal canals, both of which canals are large. The main infraorbital canal lies mainly in a deep groove on the lateral edge of the bone, the canal being wholly enclosed, at one point only, by a narrow bridge of bone. The anterior corner of the bone rests on the dorsal surface of the pterotic, and its posterior corner on the dorsal surface of the

suprascapular. Elsewhere the bone is entirely suspended in dermal tissues. Between its anterior edge and the adjoining edges of the pterotic and parieto-extrascapular, there is a large circular opening which leads directly into the anterior end of the temporal fossa.

The suprascapular has opisthotic and epiotic processes, the former process resting on and being bound by tissues to an eminence on the hind end of the opisthotic. The epiotic process rests on the dorsal surface of the suprascapular process of the epiotic, its anterior end apparently coming into contact with, but not being completely overlapped dorsally by the hind end of the parieto-extrascapular. The lateral edge of the bone is traversed by the main infraorbital canal, and gives articulation, on its ventral surface, to the dorso-anterior corner of the supraclavicular; there here being, as in Scorpaena, two articular surfaces, an articular head, and a closely adjacent articular facet.

The supraclavicular resembles the bone of Scorpaena. Its dorsal edge is traversed by the main infraorbital canal. Near its anterior edge, at or about its ventral third, it gives insertion to the occipito-supraclavicular ligament.

The parieto-extrascapular, in the two specimens examined, did not meet, in the mid-dorsal line, its fellow of the opposite side. In one of these two specimens the two bones were widely separated: in the other, a much smaller specimen, they approached each other closely at their antero-mesial corners. A considerable, but varying portion of the dorsal surface of the supraoccipital thus here comes to the dorsal surface of the skull, and on its hind edge the median portion of the supratemporal commissure lies, enclosed in dermal tissues only. The hind edge of the parieto-extrascapular overhangs but slightly the posterior surface of the skull, giving rise to a shallow supratemporal pocket.

The supraoccipital has a spina occipitalis similar to that of Scorpaena, its ventral end being held, as in Scorpaena, but to a less extent than in that fish, between thickened process-like portions of the exoccipitals. The posterior surface of the bone is crossed, as in Scorpaena, by what I there described as the hind edge of the primary skull, this edge being represented in its lateral portion by a strong ledge, but in its median portion by a low and rounded ridge.

The temporal fossa is large, and similar to that in Scorpaena; but a large circular opening between the pterotic, lateral extrascapular and parieto-extrascapular leads from it onto the dorsal surface of the skull.

The epiotic, opisthotic, exoccipital, and basioccipital are similar to those bones in Scorpaena. The exoccipital has a mesial process on its cerebral surface, as in Scorpaena. The proötic, in the specimen used for illustration, was perforated, on one side, by two small foramina lying immediately beneath the trigemino-facialis chamber, due doubtless to wear or to defects in the bone.

The bulla acustica is large, and in the angle that marks its dorsal boundary there are separate glossopharyngeus and vagus foramina, the glossopharyngeus foramen lying in the exoccipital on one side of the specimen examined in this connection, but in the sutural line between that bone and the proötic on the other side of the specimen. Posterior to the vagus foramen, the exoccipital is pierced by a foramen for the occipital nerves, as in Scorpaena.

The infraorbital chain of bones includes a lachrymal, two suborbitals and two postorbitals. The lachrymal and two suborbitals correspond to the sames bones of Scorpaena, but they are much narrower and more delicate than in that fish. The two postorbitals are delicate semicylindrical bones that extend from the dorsal edge of the second suborbital to the ventral edge of the postfrontal and bound the hind edge of the orbit. They transmit the main infraorbital canal from the second sub-

orbital to the postfrontal, the canal here forming a continuous suborbital ring, instead of being interrupted as in Scorpaena. The orbital edges of the lachrymal and two suborbitals are broadened to form a flat, curved and delicate suborbital shelf.

The lachrymal articulates, by its dorsal edge, with the ectethmoid. Its ventro-anterior corner rests upon, and is firmly bound to the ligamentary process of the maxillary, the dorso-mesial portion of its anterior edge resting upon the dorsal surface of the maxillary process of the palatine. At the hind end of this surface of contact with the palatine a short stout ligament connects the two bones. Posterior to the point of attachment of this ligament, between it and the articular surface for the ectethmoid, the large anterior primary tube of the main infraorbital canal opens on the external surface of the bone. The second and third tubes of the main infraorbital canal issue from that canal as it traverses the lachrymal, the fourth tube issuing between the lachrymal and first suborbital, as in Scorpaena. The anterior edges of the second and third tubes, one or both, are produced in short sharp spines, these being the only spines on the infraorbital chain of bones. The fifth tube opens on the lateral surface of the second suborbital bone, and the prolonged hind end of the dorsal edge of this tube reaches and is bound to the preopercular. The sixth tube lies between the dorsal edge of the second suborbital and the ventral end of the first postorbital, the seventh tube lying between the two postorbitals, and the eighth tube between the second postorbital and the postfrontal.

The hyomandibulo-palato-quadrate apparatus does not differ in any important respect from that of Scorpaena. The opercular process of the hyomandibular is not so long as in Scorpaena. The preopercular has five spines on its hind edge; but the second spine from the dorsal edge of the bone, instead of the first one, is the longest, and there is no supplementary spine either at the base of this spine or at the base of the dorsal spine, as there is in Scorpaena. The quadrate has a posterior process, the posterior surface of which is applied against and firmly bound to the ventral end of the preopercular. On the inner surface of the quadrate there is a symplectic groove which lodges the ventral portion of the symplectic. The metapterygoid has lateral and mesial flanges on its hind edge, both of which are connected with the anterior edge of the hyomandibular, as in Scorpaena: but these flanges of Sebastes do not meet to form a dorsal prolongation of the hind edge of the bone, and there is no continuation of the flanges along the dorso-anterior edge of the bone, as in Scorpaena. The ectopterygoid and entopterygoid differ but little from those of Scorpaena. The palatine is relatively shorter than in Scorpaena, and its ventral process is not so tall as in that fish. The opercular, subopercular and interopercular are as in Scorpaena.

The mandible has articular, angular and dentary elements, closely resembling those of Scorpaena.

III. Cottus octodecimospinosus.

The skeleton of the head of Cottus octodecimospinosus differs considerably, in several important respects, from that of Scorpaena and Sebastes.

1. SKULL.

The skull as a whole is relatively low and flat, and the brain case is relatively long, occupying nearly one half the length of the skull. The bones of the skull are all much thinner and more delicate than those of Scorpaena and Sebastes, the brain case being little more than a thin shell of bone.

The postorbital process of the skull is a short broad pyramidal process which lies at the anterior two-fifths, approximately, of the length of the brain case, and in the dorsal two-fifths only of the lateral surface of the skull. The process, as always, separates the orbital and lateral surfaces of the brain case, but these two surfaces here lie in nearly the same plane, the postorbital process forming simply a large ridge and not a marked angle between them, as it does in Scorpaena. Because of the position of the orbital surface of the brain case, so slightly inclined to its lateral surface, and because, also, of the absence of a basisphenoid, the orbital opening of the brain case is very large. The postorbital corner of the frontal lies in the transverse plane of the lateral bounding edges of the orbital opening of the brain case, considerably anterior to the postorbital process of the skull.

The postorbital process is formed, as usual, by portions of the proötic and sphenotic bones, and it bears a large circular facet for the anterior head of the hyomandibular. Starting from the base of the process, an angular edge runs antero-laterally toward the antero-ventral corner of the brain case, another but much more rounded edge running postero-ventrally toward the hind end of the brain case. Between these two edges and the base of the skull there is a flat smooth and raised portion of the lateral surface of the brain case, the flat bulla acustica forming the rounded dorso-posterior edge of the surface.

Anterior to this flat surface and to the postorbital process, there is a depressed region which forms the orbital surface of the brain case. Dorso-posterior to the flat surface there is, on the lateral surface of the brain case, a large triangular subtemporal depression, similar to but more extensive than the one in Scorpaena, the depression here reaching almost to the dorsal edge of the lateral surface of the skull. Anterior to this subtemporal depression, between it and the postorbital process, there is a shallow groove, which apparently represents the fossa there found in Scorpaena. In the postero-ventral corner of the subtemporal depression is the vagus foramen, the glossopharyngeus foramen lying slightly anterior to it at the ventral edge of the depression; both foramina perforating the exoccipital. The anterior corner of the subtemporal depression is shut off from the orbital surface of the brain case by the base of the postorbital process, and does not, as in Scorpaena, connect, by a groove, with the facialis opening of a trigemino-facialis chamber. Dorsal, or dorso-anterior to the dorsal corner of the subtemporal depression is the small oval facet for the posterior articular head of the hyomandibular, this facet lying wholly on the pterotic.

The DILATATOR FOSSA is small, lies directly anterior to the posterior articular facet for the hyomandibular, and almost directly dorsal to the anterior articular facet for that bone. The fossa lies partly in the sphenotic and partly in the pterotic, and is roofed by the pterotic alone, the postfrontal here lying wholly anterior to it.

The TEMPORAL FOSSA is small, and five of the six fossae in my three specimens open mainly on the lateral surface of the skull, between the opisthotic leg of the suprascapular and the posterior process of the pterotic. The usual opening, on the posterior surface of the skull, between the opisthotic leg of the suprascapular and the epiotic, is, in four of these five instances, reduced to a small opening, and in one instance almost entirely closed.

This reduction of this opening is due to the encroaching ingrowth of both the epiotic and the opisthotic leg of the suprascapular, but mainly to the marked broadening of the latter leg. When the suprascapular is removed the hind end of the fossa is found to be fairly large, and to lie at the extreme dorso-lateral corner of the hind end of the skull. The fossa, thus exposed, seems short when

viewed from above, but this is largely due to the marked elongation of the brain case; for the fossa extends from the hind end of the skull about halfway to the postorbital process, which is about its normal length. At about the middle of its length the fossa is bridged by the narrow and tubular, mesial one of the two lateral extrascapular ossicles found in this fish. Posterior to this bridge, the central portion of the fossa is without roof, its mesial edge being slightly overhung by the lateral edge of the epiotic, and its lateral edge being roofed by the lateral one of the two lateral extrascapular ossicles. Anterior to the bridge, the fossa is wholly without roof. The posterior opening of the fossa is roofed, as usual, by the suprascapular and the suprascapular process of the epiotic. The fossa thus opens on the dorsal surface of the skull by two large openings. In the mesial wall of the posterior portion of the fossa there is a pronounced preëpiotic recess.

The SUPRATEMPORAL FOSSA is as in Scorpaena, but much smaller.

There are, as is well known, three SPINES on either side of the dorsal surface of the skull, and one on the supraclavicular. The three spines on the dorsal surface of the skull form a row that corresponds to the mesial row of spines of Scorpaena, the supraclavicular spine being the only one of a lateral row.

Of the three spines that form the mesial row, the anterior one lies on the dorsal surface of the hind end of the nasal, and, projecting backward, overhangs the opening of the second primary tube of the supraorbital latero-sensory canal. The next posterior spine of the row lies on the dorsal surface of the frontal, and its relations to the supraorbital canal show that it is a frontal spine. It lies, however, near the postorbital corner of the frontal, considerably anterior to its hind edge, this position thus differing considerably from that of the frontal spine in either Scorpaena or Sebastes.

The base of the spine, in Cottus, overlies that part of the supraorbital canal that lies between the fifth and sixth tubes of that line, and projects backward toward the seventh tube or between that tube and the fifth tube. The sixth tube anastomoses with the main infraorbital canal, and it was double in each of the two specimens examined, the fifth tube being also double in one specimen. There is no spinous interorbital ridge related to the frontal spine.

From the base of the frontal spine a strong ridge begins, the occipital ridge of Jordan and Evermann's ('98) descriptions, and running backward in a curved course across the posterior portion of the frontal and then across the parieto-extrascapular, ends, at the hind end of the latter bone, in a stout spine. This spine lies partly above but mostly posterior to the supratemporal canal, its position thus not definitely indicating whether it is a parietal or a nuchal spine. It is however, in all probability, a spine developed in relation to the parietal bone, and hence a parietal spine, the ridge that terminates in it then being a parietal ridge.

The parietal ridges of opposite sides lie relatively widely apart, and that part of the dorsal surface of the skull that lies between them is flat, and corresponds to the subquadrangular groove on the vertex of Scorpaena; but here, in Cottus, there is, aside from the presence of parietal spinous ridges, no indication whatever of a groove; for the region is not depressed and there are no anterior and posterior bounding ridges whatever.

The supraclavicular spine projects posteriorly from the dorso-posterior corner of the supraclavicular, ventral to the section of latero-sensory canal that traverses the bone.

The MESETHMOID is, in all my specimens, a relatively delicate bone that extends but slightly into the underlying cartilage. It has, on either side, a short stout mesethmoid process which is directed

antero-laterally and gives attachment, on its outer end, to the ethmo-maxillary ligament. The latero-posterior, or ventro-latero-posterior, surface of the process gives support to a process on the hind end of the nasal bone, the latter bone being strongly bound to the mesethmoid process by fibrous tissues.

The ECTETHMOID has a body of delicate perichondrial bone, and a stout lateral process which corresponds to the wing and arm together of the bone in Scorpaena. On the ventral edge of this lateral process there is a single large condylar eminence, which gives articulation to the lachrymal alone, the palatine not anywhere coming into articular relations with the ectethmoid. Lateral to this articular eminence, the ventro-lateral corner of the lateral process is free. On the antero-dorsal surface of the bone there is a short but relatively large process which projects antero-mesially and gives support, on its summit, to the lateral end of a lateral process on the hind end of the nasal, this process of the nasal being strongly bound to the ectethmoid process by fibrous tissues. Between this ectethmoid process and the mesethmoid process, the lateral process of the nasal bridges the hind end of the olfactory depression, lying between the two nasal apertures. In Scorpaena scrofa, as already stated, this nasal process of the ectethmoid of Cottus is apparently represented by an eminence, or short spine, sometimes but not always found on the ectethmoid of that fish.

The VOMER has a short dorsal limb formed of thin bone, of perichondrial appearance, which comes into contact posteriorly with the perichondrial portions of the three ethmoid bones. A raised portion on the ventral surface of the anterior end of the bone bears a band of villiform teeth which extends, uninterruptedly, from one side to the other.

The PREMAXILLARY has large ascending and articular processes, the former resting on the dorsal surface of the rostral, and the latter articulating with the maxillary, as in Scorpaena. The body of the bone is shorter than in Scorpaena, extending but half the length of the maxillary and ending practically at the hind edge of its own postmaxillary process; the posterior half of the body of the bone of Scorpaena being represented, in Cottus, by tough gristly tissue. The oral surface of the bone of Cottus is furnished nearly its full length with small villiform teeth.

The MAXILLARY has a stout, right-angled ascending process which articulates with the premaxillary and, through the intermediation of a pad of semi-cartilaginous tissue, with the dorsal limb of the vomer. The antero-mesial (proximal) end of the ligamentary process is well-developed and gives insertion to the ethmo-maxillary ligament. The postero-lateral (distal) end of the process is represented by a slight eminence which gives insertion to the maxillo-mandibular ligament, this ligament having a course, and an insertion on the articular, similar to that in Scorpaena. Between these two ends the ligamentary process is but slightly if at all developed, but the dorsal surface of the shank of the bone here gives articulation to the enlarged anterior end of the maxillary process of the palatine. The ventral edge of the anterior end of the lachrymal here also comes into slight contact with the maxillary, but the lachrymal is here bound to the palatine alone, and is not supported by, and bound to the maxillary, as in Scorpaena.

The NASAL has, as already stated, a lateral process on its hind end, this process giving to the hind end of the bone an expanded appearance. This expanded hind end of the bone is bound mesially to the mesethmoid process, and laterally to the nasal process on the dorso-anterior surface of the ectethmoid, thus bridging a part of the nasal pit. The bone is traversed by the supraorbital latero-sensory canal and lodges one organ of that line. No part of the canal traverses the process that bridges the nasal sac.

The FRONTAL has a well developed ventral flange which comes into contact with the alisphenoid and sphenotic, and possibly also, in some specimens, with the dorsal end of the ascending process of the parasphenoid; but the exact relations of the bones here could not be determined, for their outlines were not distinct in either of my three skulls, and I could not disarticulate the bones in the one skull that I could spare for the purpose. Posterior to this ventral flange, there is a smaller flange on the ventral surface of the frontal, the two flanges embracing the dorsal edge of the alisphenoid, and the small posterior flange forming the dorsal portion of a partition between the fore and midbrain recesses of the cranial cavity. The ventral flanges of the frontals of opposite sides are relatively widely separated from each other and form the lateral boundaries of the dorsal portion of the wide orbital opening of the brain case.

The frontal is bounded posteriorly by the parieto-extrascapular and supraoccipital. Anterior to the latter bone it rests directly upon the postepiphysial cartilage, this part of the bone, and also the part that lies immediately anterior to it, being so thin as to be almost transparent. The hind end of the lateral edge of the bone is bounded by the pterotic, and anterior to that bone is in contact with a corner of the postfrontal.

The bone is traversed by the supraorbital canal and lodges five organs of that line, a primary tube leaving the canal between each adjoining two of the five organs. There is thus one tube more in this fish than in Scorpaena, this seeming to confirm the conclusion that a tube has disappeared in the latter fish, as already explained. The fifth frontal organ of Cottus, the sixth one of the line, lies in the small terminal tube of the canal, is well developed, and is innervated by a branch of the ophthalmicus lateralis that pierces the skull from the outside and has an intracranial course, as in Scorpaena. The penultimate, or sixth tube of the line anastomoses with that tube of the main infraorbital canal that lies between the postfrontal and pterotic.

The POSTFRONTAL has a postorbital position, and is, in appearance, the dorsal one of two postorbital bones. This bone, however, lodges the anterior one of the two infraorbital sense organs that are innervated by the ramus oticus, this definitely identifying it as a postfrontal. The hind end of the dorsal edge of the bone lies on the dorsal surface of the sphenotic, the anterior and larger part of this edge of the bone abutting against the lateral edge of the postorbital part of the frontal.

The PARIETO-EXTRASCAPULAR is traversed, near its hind edge, by the mesial section of the supratemporal latero-sensory canal, and bears at its hind edge the parietal spine. It lodges one organ of the supratemporal commissure.

The LATERAL EXTRASCAPULAR is usually represented by two ossicles, one traversed by the main infraorbital latero-sensory canal, and the other by the lateral section of the supratemporal canal, but in one of the two fishes examined, the two ossicles were fused to form a single bone. The ossicle that lodges the lateral section of the supratemporal canal bridges the temporal fossa, the other ossicle roofing the lateral portion of the postcommissural portion of the same fossa; the commissural ossicle lying at the anterior end of the infraorbital ossicle. Each ossicle lodges a single organ of the related latero-sensory line.

The SUPRASCAPULAR has a stout, pointed epiotic process which rests upon the dorsal surface of the suprascapular process of the epiotic; and a short, stout and broad opisthotic process. The latter process is directed downward and forward, its flat surface lying in a somewhat transverse

position, and, on one side of one of my three specimens, it almost entirely closed not only the posterior but also the lateral opening of the temporal fossa, leaving only small openings on either side of it. On the other side of that one specimen, and on both sides of the two other specimens, the opening lateral to the process was the larger of the two, the opening mesial to the process being practically closed in one of the two specimens. Mesial to the base of the opisthotic process there is, on the under surface of the bone, an articular facet, and directly posterior to the base of the process there is an articular eminence; the two surfaces giving articulation to the supraclavicular. The body of the bone is traversed by the main infraorbital canal and lodges one organ of that canal, innervated by a branch of the supratemporal branch of the nervus lineae lateralis. The bone is without spine.

The SUPRACLAVICULAR has, on the anterior corner of its dorsal edge, a facet which gives articulation to the articular eminence on the under surface of the suprascapular. From the mesial surface of this part of the bone a process arises, directed antero-mesially, and on its anterior end it has an articular eminence which articulates with the articular facet on the suprascapular. The dorsal edge of the bone is traversed by a short section of the main infraorbital latero-sensory canal and lodges one organ of that line. The posterior corner of the bone is prolonged into the stout supraclavicular spine.

The PARASPHENOID has, on either side, a tall and broad ascending process with two dorsal ends. These two dorsal ends are pointed and separated by a large V-shaped incisure in my small specimens, but bifid and separated by a shallow depression in the large specimen used for illustration. The posterior and shorter end, or point is directed toward, and nearly reaches the trigeminus foramen. and is in contact with and firmly bound to the proötic. The anterior and longer point is in contact with and firmly bound to the alisphenoid, and almost, if not quite reaches in certain specimens the ventral edge of the ventral flange of the frontal. These two ends, or points, belong respectively to posterior and anterior portions of the ascending process, and between the two portions the outer surface of the process is quite concave, its inner surface being correspondingly convex. Between the posterior portion of the process and the body of the parasphenoid there is a normal internal carotid foramen.

On the dorsal surface of the parasphenoid, between the bases of the ascending processes, there is a raised median portion on the dorsal surface of which there is a relatively large median pit, the point of the pit directed downward and backward. The pit gives insertion to the recti interni muscles. Immediately posterior to it there is a depressed region on the dorsal surface of the bone, and then a raised median rib, this rib lying between the ventral edges of the proötics of opposite sides and forming the median portion of the floor of the myodome.

The ALISPHENOID is bounded posteriorly by the sphenotic and proötic, with both of which bones it is in synchondrosis. Antero-dorsally it is overlapped externally by the ventral flange of the frontal, and ventrally it is in contact with the anterior portion of the ascending process of the parasphenoid. It has short but broad basisphenoid and parasphenoid legs, these two legs enclosing a V-shaped groove which begins at nothing, at the anterior end of the ventral edge of the bone, and deepens gradually toward its hind end. The external bounding plate of this V-shaped groove is the parasphenoid leg of the bone and is the part of the bone that is in contact with the ascending process of the parasphenoid. The internal bounding plate of the groove is the basisphenoid leg of the bone,

and it projects ventro-mesially into the cranial cavity of the prepared skull and terminates with a free edge.

The hind edges of the two legs of the alisphenoid are in contact with the anterior edges of corresponding plates of bone on the ventral edge of the orbital portion of the proötic; and these two plates of this part of the proötic may for convenience be called the parasphenoid and basisphenoid legs of the orbital part of that bone. The basisphenoid leg corresponds to that part of the external surface of the proötic of Scorpaena that forms the mesial wall of the jugular groove on the orbital surface of the bone; the parasphenoid leg corresponding to the membrane that spans that groove and was referred to, when describing Scorpaena, as a membranous anterior extension of the lateral wall of the trigemino-facialis chamber. This membrane having ossified, in Cottus, as part of the proötic, the jugular groove of Scorpaena becomes, in Cottus, a canal which opens anteriorly into the cranial cavity, while posteriorly it opens by a foramen-like opening onto the external surface of the proötic. The anterior end of the canal is much larger than its posterior end, and the canal is continuous anteriorly with the V-shaped space between the two legs of the alisphenoid, the two spaces together forming a recess in the cranial cavity which may be called the internal jugular recess. The internal jugular vein and the truncus ciliaris profundi enter this recess at its anterior end, and, running posteriorly, issue through the foramen-like opening at its hind end. This latter foramen is accordingly an internal jugular foramen, but it is not the strict homologue of the foramen that I have described as the internal jugular foramen in one specimen of Scorpaena; for the foramen in Cottus is bounded by the proötic and the parasphenoid alone, while in Scorpaena it is bounded by the alisphenoid, the proötic and the parasphenoid. The foramina in the two fishes result, however, from the bridging of one and the same canal by a bridge of bone that is narrow in one fish and wide in the other.

On the internal surface of the alisphenoid of Cottus, there is, as in Scorpaena, a brace-like flange, which lies between the fore-brain and mid-brain recesses of the cranial cavity. In Cottus this flange is thin and tall and forms, with a corresponding flange on the ventral surface of the frontal, a somewhat important partition between the dorsal corners of the two recesses.

The alisphenoid is perforated, in its antero-ventral portion, by a foramen which varies considerably in position in my specimens. It transmits the lateralis nerve destined to innervate the 6th. or terminal organ of the supraorbital canal, the nerve always being accompanied by a blood vessel. Whether other than lateralis fibers form part of the nerve was not investigated. The nervus trochlearis passes across the free edge of the alisphenoid without perforating it.

The SPHENOTIC is normal in position and forms, as usual, the dorsal portion of the facet for the anterior articular head of the hyomandibular and the anterior portion of the dilatator fossa. The oticus canal enters the bone on its orbital surface, and traversing the bone opens into the bottom of the dilatator fossa. A flange on the cerebral surface of the bone forms part of the anterior bounding wall of the labyrinth recess. The dorsal surface of the bone is almost entirely covered by the frontal and pterotic, comes nowhere to the level of the dorsal surface of the skull, and gives support to a part only of the dorsal edge of the postfrontal.

The PROÖTIC differs in certain important respects from the bone in Scorpaena and Sebastes. One of these differences is the enclosing of the internal jugular groove, and has just above been described. The other relates to the trigemino-facialis chamber, and is described below. The bone is

bounded as usual by the sphenotic, pterotic, exoccipital and basioccipital, and its ventral portion is overlapped externally by the parasphenoid. From the opisthotic it is separated by a considerable interval.

Immediately anterior to the base of the postorbital process, the proötic is perforated by two or three foramina, which transmit the profundus, trigeminus and facialis nerves; the profundus issuing alone through one of the foramina, where there are three, but issuing with the trigeminus where there are but two. The profundus foramen, when present, is a small canal which, running inward, either opens into the trigeminus foramen, or close to that foramen on the inner surface of the skull. The trigeminus foramen is the largest of the two or three and lies antero-dorsal to the facialis foramen, both foramina opening into a trigemino-facialis recess on the internal surface of the proötic, similar to the recess described in Scorpaena. This recess in Cottus is, however, relatively larger than in Scorpaena, and its floor as well as its roof is formed by a thin shelf-like flange of bone. The recess lodges, as in Scorpaena, the profundus ganglion and the ganglia formed on the communis and lateralis roots of the trigemino-facialis complex. The communis ganglion is a large, pear-shaped ganglion, and from it, two intracranial nerves arise. One of these nerves is the ramus palatinus facialis, which runs downward forward and mesially, perforates the horizontal ledge that forms the floor of the trigemino-facialis recess and then the prepituitary portion of the mesial process of the proötic, and so enters the myodome at its extreme dorso-lateral corner. The other nerve runs upward and backward, perforates the thin shelf of bone that forms the roof of the trigemino-facialis recess, and then continues upward and backward along the edge of the bony anterior wall of the labyrinth recess, until it reaches the roof of the cranial cavity. There it turns backward and mesially along the internal surfaces of the frontal and parieto-extrascapular, passes between those bones and the supraoccipital, and issues on the dorsal surface of the skull close to its hind edge and close to the median line. On one side of the one specimen examined, the thin roof of the trigemino-facialis recess was perforated by two foramina, the communis nerve just above described there doubtless arising from its ganglion by two strands. This nerve, in its general course, closely resembles the so-called lateralis accessorius of Gadus and Silurus, and, like the palatine, must consist largely, if not entirely of communis fibers.

In addition to these two intracranial nerves, two large nerve trunks and the smaller truncus ciliaris profundi arise from the complex and issue by the two or three foramina in the proötic. One of the two trunks is the root of the trigeminus accompanied by lateralis and communis fibers, and this root is closely accompanied by the truncus ciliaris profundi. The other trunk is the root of the facialis accompanied by lateralis and communis fibers. The truncus ciliaris profundi separates from the root of the trigeminus while still inside the cranial cavity and either issues through the trigeminus foramen, or through a separate and independent profundus foramen. It then enters the internal jugular canal through its posterior opening, and traversing that canal enters and traverses the anterior end of the myodome, and so issues in the orbit. The root of the trigeminus swells into a ganglion either as it traverses its foramen or wholly but immediately beyond that foramen, the trigeminus ganglion thus being largely or wholly extracranial in position. The facialis passes close to the hind end of this extracranial ganglion, and, as in Scorpaena, receives from its hind end a large communicating branch. Associated with the trigeminus ganglion and lying immediately ventral to it, there is, as in Scorpaena, a large sympathetic ganglion, but this ganglion here lies on the external surface of the proötic. The jugular vein and external carotid artery both come into the same rela-

tions with these two ganglia that they do in Scorpaena, but they here both lie along the external surface of the proötic.

There is thus, in Cottus, no bony trigemino-facialis chamber, the outer wall of that chamber being represented by membrane only, as it is in the 44 mm and 55 mm specimens of Scorpaena. But singularly enough, the outer wall of the internal jugular canal, which canal is simply an anterior prolongation of the trigemino-facialis chamber, has been ossified in Cottus, while in Scorpaena it is almost wholly membranous. In the specimen of Cottus used for the figure, two little eminences on the outer surface of the proötic indicate a partial ossification of the outer wall of the trigemino-facialis chamber. In the other two of my three specimens these eminences did not exist, the bone there being simply slightly hollowed where the trigemino-facialis foramina perforated it.

The proötic of Cottus has a perfectly normal mesial process, connected, by intervening cartilage, with its fellow of the opposite side. The prepituitary portion of the process is short, not reaching the middle line. The pituitary opening is thus not closed anteriorly by bone, and so forms an apparent part of the large orbital opening of the brain case. The membrane that closes the latter opening is greatly thickened in the optic and basisphenoid regions, and there becomes a thick, tough, fibrous structure the lateral edges of which are attached to both edges of the internal jugular recess. The nervus oculomotorius pierces this membrane, on either side, near its lateral edge and enters the myodome, lying, in this part of its course, between the ascending process of the parasphenoid and the basisphenoid membrane, and hence morphologically between the two legs of the alisphenoid; its normal position. A median, encephalic artery, formed by the union of the internal carotids of opposite sides, pierces the membrane near the anterior edge of the membranous pituitary fossa, and enters the cranial cavity.

The MYODOME is well developed; and it would seem as if the skull of this fish must have been unknown to Cope when he placed the Cottidae among those fishes in which the canal is wanting. The hind end of the canal is continued a short distance in the basioccipital, but it does not open posteriorly on the outer surface of the skull.

The PTEROTIC presents no features differing especially from those of the bone in Scorpaena, excepting that it lodges two sense organs of the main infraorbital line, one innervated by the ramus oticus and the other by the supratemporal branch of the nervus lineae lateralis vagi; the preopercular canal joining the main infraorbital between these two organs. The bone accordingly contains a post-preopercular latero-sensory ossicle, this ossicle not being found in either Scorpaena or Sebastes.

The BASIOCCIPITAL is much less deeply and extensively grooved by the posterior portion of the myodome than in Scorpaena, and the cavum sinus imparis is simply a shallow depression. The bone forms part of the boundary of the foramen magnum, as in Scorpaena, and otherwise resembles the bone in that fish.

The EXOCCIPITAL is perforated by three foramina, as in Scorpaena, but the occipital foramen is very small and represents a part only of the foramen of Scorpaena; a deep incisure in the hind end of the exoccipital, immediately dorsal to the base of its condylar process, transmitting the larger part of the nerves that traverse the occipital foramen in Scorpaena. The bone, as in Scorpaena, has a mesial process, which rests on the dorsal surface of the basioccipital and roofs the hind end of the saccular groove.

The EPIOTIC has on its posterior surface, an epiotic ridge, which projects postero-laterally to an unusual extent and nearly meets the opisthotic process of the suprascapular; thus nearly or even quite closing the posterior opening of the temporal fossa.

The SUPRAOCCIPITAL has dorsal and ventral limbs, the former of which is largely exposed, on the dorsal surface of the skull, between the frontals and parieto-extrascapulars. The hind edge of the dorsal limb projects backward, forming a short horizontal plate-like process which slightly overhangs the ventral limb and rests upon, and is fused with, the dorsal edge of the spina occipitalis.

2. INFRAORBITAL BONES.

The infraorbital bones are, as in Scorpaena, four in number; a lachrymal, two suborbitals, and a postorbital.

The lachrymal is concave on its outer and convex on its inner surface. It has a short anterior edge, the ventral half of which lies upon the lateral edge of the broad anterior end of the maxillary process of the palatine, and is very firmly bound to it by tissue. The dorso-anterior corner of the bone bears, on its dorsal edge, a large concave articular facet which articulates with the articular head on the ventral edge of the lateral process of the ectethmoid. The mesial edge of this facet is greatly thickened and forms a stout process projecting mesially, the outer end of which is deeply grooved. The ventro-anterior surface of this process is rounded, and fits against and is firmly bound to the bottom of a unshaped depression on the external surface of the palatine; some slight motion being possible between the two pieces. The groove on the outer edge of the process is presented posteriorly, is free, and simply gives attachment to tissues of the region. The bone lodges two sense organs of the main infraorbital line, instead of three as in Scorpaena, the third and fourth organs of the line here both lying in the first suborbital.

The first suborbital is a short and irregular bone, and lodges two sense organs, instead of a single one, as in Scorpaena.

The second suborbital is long and extends backward to the anterior edge of the preopercular, either touching, or almost touching that bone, and being bound to it by tissue. A broad, low and rounded ridge extends the full length of its outer surface. The main infraorbital canal traverses the anterior two-fifths of the bone in a nearly horizontal position and then turns abruptly upward to enter the postorbital bone, giving off at the bend a short tube directed ventro-posteriorly, this tube being double in the specimen used for illustration. The bone lodges two sense organs, one lying anterior and the other posterior (here dorsal) to this tube. The posterior three-fifths of the bone, and the ridge on its outer surface, are thus not developed in any apparent relation to any of the tubes of the latero-sensory canal.

The postorbital bone is bound to the dorsal edge of the second suborbital at about the anterior two-fifths of its length, and it and the postfrontal form a slightly curved line which is convex anteriorly and directed upward and backward to join the dorso-lateral edge of the skull at the sutural line between the frontal and pterotic. The two bones lie slightly posterior to the orbit, the hind edge of the orbit being formed by a stiff membrane that is attached to the anterior edges of the two bones. The post-orbital lodges a single latero-sensory organ.

3. SUSPENSORIAL APPARATUS AND MANDIBLE.

The PREOPERCULAR is a stout bone with dorsal and ventral limbs lying at somewhat more than a right angle to each other. In their natural positions the dorsal limb is directed dorso-anteriorly and the ventral limb ventro-anteriorly. The dorsal portion of the dorsal limb rests against and is firmly bound by tissue to the grooved hind edge of the hyomandibular, its dorsal end not extending beyond the opercular process of that bone. The ventral portion of the ventral limb rests against and is firmly bound to the grooved postero-ventral surface of the posterior process of the quadrate. Between these two portions of the preopercular a large and thin web of bone extends across the angle between the two limbs and supports, on its internal surface near its ventral end, that part of the hyomandibulo-symplectic interspace of cartilage on which lies the articular facet for the interhyal. Dorsal to that facet, the web of bone is thickened to form a process-like portion, and the edge of this portion is bound by tissue to the hind edge of the ventral portion of the hyomandibular. At the dorsal end of the web there is an incisure, through which, between the preopercular and the hind edge of the hyomandibular, the ramus hyoideus facialis passes from the outer to the inner surface of the apparatus.

The large and well known preopercular spine of the fish extends posteriorly in the direction of the ventral limb of the bone, and almost as a posterior continuation of that limb. A second one of the three preopercular spines lies directly ventral to this large one, either parallel with it, or directed ventro-posteriorly at an angle to it. The third preopercular spine arises from the ventral edge of the ventral limb of the bone, close to its anterior end. The bone is traversed its full length by the preopercular latero-sensory canal and lodges five sense organs of that canal.

The HYOMANDIBULAR has anterior and posterior heads for articulation with the cranium, and a very stout head for articulation with the opercular. The shank of the bone is relatively broad and thin, and the longitudinal ridge on its outer surface is short, but stout. The bone is traversed by a facialis canal, which opens on the outer surface of the shank anterior to the longitudinal ridge, and also by a short branch canal which opens on the outer surface of the bone posterior to the ridge. A large web of bone fills the angle between the anterior articular head and the shank of the bone, and is in contact with and is firmly bound by tissue to the hind edge of the metapterygoid.

The SYMPLECTIC has a broad flat dorsal end, and from there tapers rapidly into a long rod-like ventral portion which lies in the symplectic groove on the inner surface of the quadrate. There is a canal along its anterior edge, between it and the anterior edge of the symplectic groove on the quadrate, which transmits the ramus mandibularis internus facialis.

The QUADRATE has a stout and long posterior process which is separated from the body of the bone by a shallow incisure. Anterior to the dorsal portion of the process, between it and the symplectic, there is a long oval opening which transmits the ramus mandibularis externus facialis and the arteria hyoidea. The posterior process of the quadrate is so long that it almost completely shuts the preopercular off from bounding participation in this opening. Along the anterior edge of the base of the process there is, on the inner surface of the body of the quadrate, a symplectic groove. From the inner surface of the anterior edge of the bone a stout ligament arises and running forward joins the tendon A_2A_3-A_0.

The METAPTERYGOID is large and flat, and without evident flanges on its hind edge. This edge of the bone is however in contact with the anterior edge of the flange on the anterior edge of

the hyomandibular, this contact being a characteristic of the flanges of the metapterygoids of Scorpaena and Sebastes, and not of the bodies of those bones. The bone is perforated, in Cottus, in its dorso-posterior portion, by a foramen which transmits the external carotid artery from the external to the internal surface of the palato-quadrate apparatus. Immediately internal to the foramen, the carotid falls into the arteria hyoidea at a sharp bend in that artery, the arteria hyoidea there turning almost directly backward to enter the opercular hemibranch. The arteria hyoidea, ventral to this bend, lies at first along the internal surface of the metapterygoid, but comes to the outer surface of the apparatus through a large fenestra between the metapterygoid, hyomandibular and symplectic. It then crosses the external surface of the symplectic and passes to the internal surface of the apparatus through the opening between the symplectic and preopercular, the mandibular artery being here given off, as in Scorpaena. The relations of these two arteries to the metapterygoid would thus be the same as those in Scorpaena, if those parts of the hind edge of the bone of Cottus that lie dorsal and ventral to the foramen for the external carotid represented respectively the internal and external flanges on the hind edge of the bone of Scorpaena; and this is certainly the case, the ventral edge of the internal flange abutting against and fusing with the dorsal edge of the external flange, and the foramen for the carotid, in Cottus, representing the greatly reduced V-shaped space between the two flanges in Scorpaena. The relatively large fenestra that transmits the arteria hyoidea is then the homologue of the small opening that transmits that artery in Scorpaena.

The efferent pseudobranchial artery is as in Scorpaena.

The ECTOPTERYGOID and ENTOPTERYGOID are in normal position, the latter bone being relatively long.

The PALATINE has a short body and a long but low ventral flange, this flange being wholly without teeth and its hind end being prolonged posteriorly in a tapering point which lies against the ventral surface of the dorsal limb of the ectopterygoid. On the lateral surface of the body of the palatine, anterior to the base of the process-like posterior extension of its ventral flange, there is a deep U-shaped depression, the legs of the U being directed posteriorly. In the posteriorly directed hollow of this U, the process on the mesial edge of the articular head of the lachrymal is received, and is firmly bound to it by tissues, some slight motion between the parts being possible. The body of the palatine is in synchondrosis posteriorly with a well formed rod of cartilage which lies along the dorsal surface of the dorsal limb of the ectopterygoid and connects the body of the palatine with that portion of the palato-quadrate cartilage that lies between the quadrate and metapterygoid.

The maxillary process of the palatine is stout and its distal end is expanded into a broad flat portion which rests upon and is firmly bound to the dorsal surface of the maxillary. At the base of the process there is a small process directed dorso-mesially. This process is strongly bound by tissue to the lateral edge of the ethmoid cartilage, but does not have articular contact with that cartilage. In Scorpaenichthys this process is large, and articulates with a large articular surface on the lateral edge of the ethmoid cartilage. In Cottus, the lateral surface of the little process gives insertion to the rostro-palatine ligament. The vomero-palatine ligament is relatively long, arises from the hind edge of the raised, toothed portion of the vomer, and running postero-laterally is inserted on the internal surface of the body of the palatine.

The anterior and posterior ethmo-palatine articulations are thus both wanting in Cottus, the posterior articulation being replaced by the articular connection of the palatine with the lachrymal.

In Hydrocyon also, both articulations are wanting, according to Sagemehl ('84 b, p. 95), and in the Cyprinidae, according to the same author ('91, p. 582), the posterior articulation is replaced by an articulation of the entopterygoid with the ectethmoid.

OPERCULAR BONES.

The opercular is so firmly bound by articular ligaments to the stout opercular articular head of the hyomandibular that it is capable of but little movement. From its articular head a stout raised portion runs posteriorly or postero-ventrally across the outer surface of the bone and terminates in the stout opercular spine; the point of that spine extending slightly beyond the point of the large preopercular spine and lying slightly dorsal to it.

The subopercular is an angular bone that embraces the ventral corner of the opercular. It bears a short, small spine at its ventral corner.

The interopercular is long and tapering. Its broad hind end is bound by tissue to the ventral portion of the anterior edge of the subopercular, but it is separated from that edge by a considerable interval, bridged by a connecting sheet of tissue. Its pointed anterior end is bound by ligament to the lateral surface of the hind end of the mandible.

MANDIBLE.

The mandible is long and rather slender, and has angular, articular and dentary elements that offer no special peculiarities. The dentary lodges three latero-sensory organs, and the articular one organ. The summit of the coronoid process of the articular is separated by a considerable interval from the hind end of the dorsal limb of the dentary, the intervening space being filled by a tough pad of fibrous tissue. In the mandibular labial fold there is a gristly core, as in Scorpaena, but it is smaller than in that fish.

4. MUSCLES.

The adductor mandibulae of Cottus resembles closely that of Scorpaena. The superficial division, A_1, of the muscle arises from the anterior portion of the external surface of the preopercular and runs almost directly forward, lying external to the levator arcus palatini and to the deeper division, A_2A_3, of the adductor. It terminates anteriorly in a tendinous band which extends the full length of its anterior edge and is inserted dorsally on the maxillary, while ventrally it joins and becomes part of the tendon A_2A_3. The deeper division of the muscle, A_2A_3, is incompletely separated into superficial and deeper portions, the superficial portion, A_2, lying superficial and ventral to the levator arcus palatini and the deeper portion lying internal to that muscle. The two muscles have their origins, as in Scorpaena, from the anterior portion of the external surface of the preopercular, ventral to the muscle A_1, and from the external surface of the palato-quadrate apparatus. Running almost directly forward, certain fibers of the muscle pass directly into the mandible and are continuous with the fibers of A_ω, others are inserted on the ventral end of the tendinous band that edges the anterior end of the muscle A_1, while the larger portion have their insertion on a tendinous structure that forms on the inner surface of the muscle and runs forward and downward into the mandible. In the mandible this tendon separates into four portions, two of which give origin to the fibers of A_ω, the other two lying one external to the other and having their insertions on the internal surface of the articular near the hind end of Meckel's cartilage. From

this tendon, A_2A_3-A_ω, a ligamentous band runs backward and is inserted on the internal surface of the quadrate.

The levator arcus palatini runs downward internal to A_1 and then internal to A_2, lying always external to A_3 and also always external to the palato-quadrate. The course of the muscle is thus in accord with the conclusion, already stated, that the dorsal portion of the hind edge of metapterygoid of Cottus represents the inner one of the two flanges on the hind edge of the metapterygoid of Scorpaena.

The dilatator operculi arises partly in the dilatator fossa, but mainly on the external surface of the dorsal end of the hyomandibular and on adjacent portions of the preopercular, and is inserted on the opercular as in Scorpaena.

The adductor hyomandibularis, and adductor and levator operculi are as in Scorpaena, but the latter muscle is represented by several separate bundles of muscle fibers all of which extend from the dorso-lateral edge of the skull to the dorsal edge of the opercular or subopercular; the posterior bundles being delicate bands lying in the membrane that closes the dorsal end of the opercular opening.

5. LATERO-SENSORY CANALS.

The main infraorbital canal of Cottus traverses the four infraorbital bones without interruption, and then enters and traverses the postfrontal, at the dorsal end of which it anastomoses with the penultimate tube of the supraorbital canal. It then turns sharply backward and traverses in succession the pterotic, lateral extrascapular, suprascapular and supraclavicular. The lachrymal lodges two sense organs of the line; the first suborbital bone lodges two regular organs and, in the one specimen examined, what was apparently a much smaller and additional organ between the two regular organs; the second suborbital bone lodges two organs; and the postorbital bone one organ: all of these organs being innervated by branches of the buccalis lateralis. The number of organs in this part of the line, excepting the small and apparently supplemental organ in the first suborbital, is thus exactly the same as in Scorpaena, but the third latero-sensory ossicle has, in Cottus, fused with the fourth ossicle and so forms part of the first suborbital bone instead of fusing with the first and second ossicles to form part of the lachrymal.

The postfrontal lodges one organ, innervated by a branch of the oticus lateralis; the pterotic two organs, one innervated by the oticus lateralis and the other by a branch of the supratemporalis lateralis vagi; the lateral extrascapular and suprascapular one organ each, innervated by branches of the supratemporalis lateralis vagi; and the supraclavicular one organ, innervated by the first branch of the lateralis vagi. This part of the line thus differs from that in Scorpaena only in that the pterotic lodges an organ innervated by the lateralis vagi; the dermal component of that bone thus being formed by the fusion of two latero-sensory ossicles.

The supratemporal commissure lodges two sense organs on either side, one lying in the lateral extrascapular and the other in the parieto-extrascapular, both innervated by branches of the supratemporalis lateralis vagi.

The supraorbital canal traverses the nasal and frontal bones, and anastomoses by its penultimate primary tube with that infraorbital tube that lies between the postfrontal and pterotic bones. The canal contains six sense organs, one lying in the nasal and five in the frontal, all innervated by branches of the ophthalmicus lateralis. A primary tube leaves the canal between each two adjoining

organs, there thus being one more tube than in Scorpaena, that additional tube lying between the fourth and fifth organs of the line. The fourth tube of the line anastomoses, in the middle line of the head, with its fellow of the opposite side, thus forming a frontal commissure, as in Scorpaena.

The preoperculo-mandibular canal traverses the dentary, articular and preopercular bones, but did not anastomose, at its dorsal end, in the one specimen examined, with the main infraorbital canal: this specimen thus differing, in this, from the specimen examined in connection with one of my earlier works ('04). It contains nine sense organs, three lying in the dentary, one in the articular and five in the preopercular, all innervated by branches of the mandibularis externus facialis.

Most if not all of the primary tubes branch one to several times after they leave the bones to which they are related and enter the cutis, but no interanastomoses of these tubes were found.

II. CRANIOMI.

I. Trigla hirundo.

1. SKULL.

Of the Triglidae I have selected Trigla hirundo for detailed descriptions, a short separate description being also given of Trigla lyra. The other members of the family examined are referred to only as they differ markedly from hirundo.

The dorsal surface of the skull of Trigla hirundo consists of two portions lying at slightly different levels. The higher portion forms by far the larger part of the dorsal surface of the skull, extending from the anterior ends of the nasals to the hind ends of the suprascapulars, and being covered, in the recent state, by a thin cutis only. The deeper portion is small, forms the dorsal surface of the anterior end of the snout, and is covered, in the recent state, by the rostral and the dermal and connective tissues that surround that cartilage.

The bones that form the larger, higher portion of the dorsal surface are all firmly bound together, and present an even surface everywhere similarly marked with little granulations arranged more or less distinctly in lines or ridges. At its anterior edge this part of the skull projects, eaves-like, above the hind edge of the deeper, anterior portion, this giving to this higher part of the prepared skull somewhat the appearance of a carapace, or, to use the expression employed by Gill in his descriptions of Dactylopterus, a „bony casque". This casque-like dorsal portion of the skull is somewhat rectangular in general outline, this being more marked in medium-sized than in large specimens. Its anterior and posterior edges are deeply concave, and there are deep, sometimes almost semi-circular incisures for the orbits. The mid-dorsal line is slightly convex, the amount and manner of the convexity varying with the size of the specimen. In medium-sized specimens the mid-dorsal line is nearly straight from its hind end to the middle of the orbits. Then it curves slightly downward to the anterior end of the orbits, where it again becomes nearly straight, and so continues to its anterior end. In the large specimen used for the drawings, the interorbital portion is, on the contrary, markedly flat and straight and is joined by slightly rounded angles to the straight anterior and posterior portions of the surface.

The mid-ventral line of the skull is concave, and has, as the mid-dorsal line has, posterior and anterior portions that are nearly straight and that are separated by an obtuse and rounded angle. The whole skull thus appears bent downward in its anterior half.

On the anterior portion of the dorsal edge of the orbit there are, in all my medium-sized specimens, two backwardly directed spines, but in my two large specimens there is but one spine, a

large one, with one or two adjoining eminences rather than spines. Near the hind edge of the orbit there is, in medium-sized specimens, a short and somewhat blunt spine, which is not evident in the large specimens. The only other spines found on the head of the fish are two spines, or eminences, on the hind edge of the preopercular, and two spines on the opercular; only one of these latter spines showing on the outer surface of the fresh head.

Between the orbits, in medium-sized specimens, the dorsal surface of the skull is deeply concave transversely, while in large specimens it is much less so; and in all specimens there is here no longitudinal ridge, on either side, to mark, as in Scorpaena, the course of the supraorbital laterosensory canal. The crown of the head is flat, the subquadrangular groove on the occiput, so characteristic of the Scorpaenidae, being slightly indicated in my medium-sized specimens by two little tuberculated and longitudinal ridges, one on either side, on the dorsal surface of the parieto-extrascapular bone. These ridges are not evident in the large specimens. The preorbital portion of the skull is relatively long, low and broad, the casque-like portion of its dorsal surface here being convex transversely and having straight lateral edges which converge but slightly forward; the casque being two-thirds or even three-fourths as wide at its deeply concave anterior end as it is at the anterior edges of the orbits.

The curved anterior ends of the lachrymals project forward and mesially, on either side, beyond the anterior end of the skull, and, with the concave anterior end of the casque, nearly enclose a subcircular space in which the rostral lies. The anterior edge of the lachrymal is, in all my specimens, serrate rather than being, as stated by Günther ('60), furnished with prominent spines.

The dorsal surface of the casque is formed by the nasals, mesethmoid, ectethmoids, frontals, postfrontals, pterotics, parieto-extrascapulars, lateral extrascapulars and suprascapulars, and also by a small portion of the sphenotic which comes to the level of the other bones and presents the same granulated appearance. The supraoccipital and epiotics are almost entirely, or even entirely covered by the overlying frontals, parieto-extrascapulars and suprascapulars.

The mesethmoid and ectethmoids come, as just above stated, to the level of the dorsal surface of the other bones that form the casque-like portion of the skull, and, having the same surface markings as those other bones, they form with them a uniform and continuous surface. They each contain the two somewhat different components, dermo-perichondrial and endosteal, referred to when describing these same bones in Scorpaena; but here, in Trigla, the dermal portion of the dermo-perichondrial component is much more important.

The MESETHMOID, as seen on the dorsal surface of the skull, is sometimes, as Günther ('60) says of the corresponding bone in Trigla gurnardus, a sexangular bone, once and a half as long as broad; but the two posterior corners of the bone thus described, are usually replaced, in medium-sized specimens, by a single point, the bone then being pentangular. The outer surface of the bone is marked by granulated ridges that all converge toward the central point of the bone, and in the substance of the bone, and converging toward this same point, there are tapering spaces. These spaces lie in the dermal portion of the bone, between the dense outer surface of this portion of the bone and the thin perichondrial layer, and the concave anterior edge of the bone is honeycombed by the openings of the spaces. This anterior edge of the dermal portion of the bone is grooved, the dense superficial layer of the bone projecting eaves-like above the deeper perichondrial layer. This latter layer extends anteriorly slightly beyond the dermal layer, and is there bounded, in the middle line,

by the hind end of a narrow and low median ridge of cartilage which represents the relatively tall internasal ridge of Scorpaena. On either side of this ridge the mesethmoid is bounded by the hind edge of the corresponding ascending process of the vomer.

The mesethmoid is bounded, on either side, in its posterior half or two-thirds, by the ectethmoid, the hind end of the mesethmoid usually projecting beyond the bounding portions of the ectethmoids and there suturating with or being overlapped externally by the frontals. The anterior half or third of the bone gives support, on either side, to the nasal, the mesial half of the latter bone overlapping and lying upon a depressed lateral half of the dorsal surface of this part of the mesethmoid. The antero-lateral corner of the dorsal surface of the mesethmoid projects forward as a sharp process, and from this process and from the ventral surface of the overlying nasal, the ethmo-maxillary ligament has its origin. This little corner or process of the mesethmoid, together with the adjacent parts of the flat dorsal surface of the bone, thus replace functionally, in their relations to the nasal bone and the ethmo-maxillary ligament, the pronounced mesethmoid process of the Scorpaenidae.

The lateral edge of the mesethmoid, beneath the nasal, is grooved and forms the median wall and part of the floor of the shallow nasal pit. Posterior to the nasal, this same grooved edge of the mesethmoid forms the mesial wall of the olfactory canal through the antorbital process. Dorsal to this groove, between it and the thin dense external plate of the bone, there is another groove in the lateral edge of the bone, this groove lying between the suturating edges of the mesethmoid and ectethmoid. A canal is thus here formed between the two ethmoid bones, which, in large specimens, may become entirely enclosed in the mesethmoid alone, continuing posteriorly to the hind edge of that bone. It lodges that part of the supraorbital latero-sensory canal that lies between the frontal and nasal bones, but contains no sensory organ, the sensory canal thus here being secondarily and not primarily enclosed in the bone.

Under the central portion of the bone, primary ossification has begun, and, in large specimens, extends entirely through the cartilage of the snout. In the central portion of this part of the bone, in three specimens that were bisected, there was a large cavity filled with fatty tissue.

The ECTETHMOID has a convex dorsal surface, this convexity being so great in the posterior portion of the bone that a transverse section here has the shape of a quadrant of a circle. The external surface of the bone lies, as already stated, on a level with the corresponding surface of the other bones of the dorsal surface of the skull, and is marked by radiating and granulated ridges. The hind edge of the bone is thin and sharp, and projects posteriorly to form the anterior portion of the roof of the orbit. It bears the two or three preocular spines, the postero-mesial one of these spines being considerably longer than the others. The mesial edge of the bone suturates, in its posterior portion, with the frontal, and, in its anterior portion, with the mesethmoid and the hind end of the nasal. Along the mesial edge of the posterior portion of the bone, beneath the overlying frontal, there is a small canal which transmits the ramus ophthalmicus superficialis, this canal leading from the orbit into that larger canal, already described, that lies between the mesethmoid and ectethmoid and that lodges the supraorbital latero-sensory canal.

The ventral surface of the ectethmoid is large and inclines downward and mesially at an angle approximately of 30° with a horizontal plane. Along the lateral edge of this surface there is a stout and irregular longitudinal ridge which projects downward and but slightly laterally. The anterior half of this ridge has a somewhat rounded summit, and this part of the ridge gives articulation to

the united lachrymal and palatine bones in a manner that will be described when describing those bones. It may however here be stated that the two articulating surfaces do not seem to come into close contact, being separated by a line of tough fibrous tissue which not only binds the bones strongly together but permits of a sort of swinging movement. The larger part of this articulation, such as it is, is with the lachrymal, the articulation with the palatine being limited to the extreme anterior end of the ridge, and the articulating surfaces there apparently coming into closer contact than elsewhere. The posterior half of the ridge is double, having mesial and lateral portions which diverge slightly. The mesial portion is a direct posterior prolongation of the anterior, articular portion of the entire ridge, but it is low and narrow, and curving ventro-mesially vanishes near the hind edge of the ventral surface of the bone. The other, lateral portion of the ridge is taller and more important than the mesial one, and running posteriorly and slightly laterally, soon becomes continuous with the posterior portion of the lateral edge of the bone. On the lateral surface of this portion of the ridge the dorsal edge of the second infraorbital bone slides as the hyomandibulo-palato-quadrate apparatus swings inward and outward.

The anterior end of the ventral surface of the ectethmoid projects forward beyond the rest of the bone as a thin flat process, of perichondrial appearance, which lies upon the ventral surface of that lateral portion of the ethmoid cartilage that forms the floor of the nasal pit; the lateral edge of the process of the ectethmoid projecting slightly lateral to the lateral edge of the overlying cartilage and so forming part of the floor of the nasal pit. The process extends forward onto the base of an anterior palatine process of the ethmoid cartilage, its anterior end there being overlapped externally (ventrally) by the small lateral process of the vomer.

The anterior palatine process of the ethmoid cartilage is a pronounced eminence on the lateral edge of the snout, bounded antero-mesially by the ascending process of the vomer, postero-mesially by the mesethmoid, and posteriorly by the process, just above described, of the ectethmoid. Ventrally it lies upon the dorsal surface of the body of the vomer, but projects laterally considerably beyond that bone. With the latero-ventral surface of the process the palatine articulates. The summit of the process always closely approaches, and is sometimes apparently in actual contact with, the ventral surface of the lateral edge of the nasal, near its anterior end; this relation of the process to the nasal varying considerably in different specimens. In most specimens a slight interval seems to separate the two structures.

The posterior, orbital surface of the ectethmoid lies at an angle to its ventral surface, the two surfaces being separated by a sharp ridge. This ridge, or angle, corresponds to the orbital rib of my descriptions of Scomber, and to a slight ridge which, in Scorpaena, extends dorso-laterally from the ventro-mesial corner of the orbital surface of the bone to the point of insertion of the posterior ethmo-palatine ligament. This latter ligament is, in Trigla, double, the two ligaments found partly fused in Scorpaena, here being wholly and quite widely separated. One of these ligaments is a flat band which has its origin on the ventro-lateral surface of the orbital ridge above referred to, and, running downward and forward, is inserted on the palatine cartilage in a manner to be later described. The other is a slender and delicate ligament which has its origin on the ventral surface of the ectethmoid and, running downward and forward, is also inserted on the palatine cartilage.

The orbital surface of the ectethmoid of Trigla thus corresponds to one half only of the same surface of the bones of Scorpaena and Scomber. The other half of this surface must then be looked for in what is apparently, in Trigla, the ventral surface of the bone, and it seems probable that it is

represented in that part of that surface that lies between the two diverging, posterior portions of the articular ridge near its lateral edge. The ventro-lateral corner of the wing of the bone of Trigla, which forms a sharp spine-like corner, is certainly the homologue of the rounded angle in the lateral edge of the wing of Scorpaena, and the anterior end of the anterior, single portion of the articular ridge of Trigla must be the homologue of that process-like portion of the bone of Scorpaena that gives articulation to the palatine. The lachrymal articular process of the bone of Scorpaena must then be represented in some part of the articular ridge of Trigla that lies between its anterior and posterior ends.

The small orbital surface of the ectethmoid of Trigla is strongly concave, converging forward and inward to a large opening which leads into the hind end of a large median chamber in the ant-orbital cartilage, the chamber perforating the extreme ventro-anterior portion of the interorbital septum. This chamber is bounded laterally, on either side, by the primary portion of the corresponding ectethmoid, and its floor is perforated by a circular opening which is closed ventrally by the underlying parasphenoid. From the chamber, on either side, a canal leads forward into the nasal pit and transmits the olfactory nerve of its side, this canal lying between the mesethmoid and ectethmoid bones and becoming, in my large specimens, a large vacuity in those two bones, filled with loose fatty tissue. Anterior to this vacuity, there was, in the mesethmoid bone alone of the three specimens examined in this connection, a separate median vacuity, already referred to, which opened on the ventral surface of the bone. The oblique muscles of the eye extend into the median chamber and have their origins there, the chamber thus being an anterior eye-muscle canal. Immediately lateral to the opening that leads from the orbit into the anterior eye-muscle canal, there is, in the ectethmoid, a small canal which transmits an artery coming from the orbit. Considerably lateral to this canal there is another smaller canal, also in the ectethmoid, but no structure, either nervous, arterial or venous could be found traversing it.

The NASAL is a somewhat quadrilateral bone that forms the antero-lateral corner of the casque-like dorsal surface of the skull. The lateral portion of its hind end rests upon the dorsal surface of the ectethmoid. Its mesial half overlaps externally and is quite firmly bound to the lateral portion of the dorsal surface of the mesethmoid. Its anterior edge forms the lateral portion of the concave anterior edge of the casque of the skull. Its antero-lateral corner projects beyond the underlying corner of the mesethmoid and also beyond the anterior palatine articular eminence of the ethmoid cartilage, and is thickened by accretions to its ventral surface. This thickened portion rests partly upon the dorso-lateral surface of the base of the maxillary process of the palatine, and partly upon the external surface of a small flat process on the dorsal edge of the lachrymal. The lachrymal and palatine are here immoveably bound together, and the extent of the contact of one or the other with the nasal varies in different specimens. The nasal is strongly but somewhat loosely bound by dermal or fibrous tissues to both the palatine and lachrymal, and gives sliding articulation to them when the palato-quadrate and cheek-plate swing inward and outward; the sliding contact being mainly with the lachrymal. The ventral surface of this corner of the nasal closely approaches, and, as already stated, may even rest upon the summit of the anterior palatine process of the ethmoid cartilage, the palatine articulating with the latter process by an articular surface at the base of its maxillary process.

Between the summit of the anterior palatine process of the ethmoid cartilage and the projecting antero-lateral corner of the mesethmoid, the nasal roofs a large passage which leads from the rostral depression into the anterior end of the nasal pit. The nasal pit is a deep low fossa in the lateral edge

of this part of the skull, lying between the nasal above, the mesethmoid and the cartilage of the snout mesially and below, the ectethmoid posteriorly and below, and the anterior palatine process of the ethmoid cartilage anteriorly. The pit is not large enough to lodge the entire nasal sac, a part of the sensory portion of the sac extending laterally, beyond the lateral edge of the skull, onto the dorsal surface of the palatine, and there lying between the palatine and lachrymal bones. A mesial diverticulum of the sac, corresponding to that in Scorpaena but somewhat differently disposed, runs forward and mesially through the passage that leads from the nasal pit into the rostral depression, and then turns mesially behind the rostral, between it and the anterior end of the mesethmoid, and abuts against but is apparently not continuous with its fellow of the opposite side.

The nasal bone is traversed by the supraorbital latero-sensory canal, and lodges one organ of that line, the anterior opening of the canal lying at the extreme antero-lateral corner of the bone. De Sède de Liéoux ('84, p. 111) says that the cephalic portion of the latero-sensory canals is absent „chez les Trigles", Trigla hirundo being the species particularly examined. This is far from being true, as will appear in the course of my descriptions.

The VOMER has ascending processes which are in contact, posteriorly, with the anterior end of the thin perichondrial layer of the mesethmoid. The ascending processes of opposite sides enclose between them, as in Scorpaena, the anterior portion of an internasal ridge of cartilage, the bone and cartilage here being, in medium-sized specimens, raised into a slight ridge, while in large specimens they become a prominent knob with a flat summit. The cartilaginous rostral slides backward and forward on this ridge or knob. The lateral corner of the ascending process of the vomer is slightly raised and embraces the anterior edge of the base of the anterior palatine process of the ethmoid cartilage; this raised or process-like portion of the vomer of Trigla corresponding strikingly, in position, to the septomaxillaries of Sagemehl's figures of the Cyprinidae. Antero-mesial to this little process there is a rounded eminence, prominent in large specimens, near the anterior edge of the dorsal surface of the bone. The lateral surface of this eminence, and the slight hollow between it and the palatine process, give articulation to the ventral edge of the ascending process of the maxillary, a pad of tough fibrous or semi-cartilaginous tissue lying between the two surfaces.

The ventral surface of the convex anterior edge of the vomer is slightly raised, and is furnished with an uninterrupted band of small villiform teeth. Immediately posterior to the lateral end of this band of teeth, there is a large depression which gives insertion to the very slightly developed vomero-palatine ligament. A slightly developed lateral process projects postero-laterally, extending beyond the anterior edge of the ventral plate of the ectethmoid and there lying upon the ventral surface of that plate.

In Trigla lineata the anterior end of the vomer is bent abruptly, though but slightly, downward; and although this is a natural formation, it has decidedly the appearance of having been produced by a blow on the end of the snout of the fish.

The PREMAXILLARY has a broad oral surface, covered its full length with small villiform teeth. At about the middle of the length of the bone, there is a thin flat postmaxillary process directed backward and slightly upward. This process forms the hind end of a pronounced longitudinal ridge on the internal surface of the bone, this ridge representing a thickened part of the bone, of membrane origin, which lies slightly dorsal to its tooth-bearing portion. This membrane component of the bone has a thin, flat and rounded hind (distal) end, which forms the postmaxillary process of the bone, and

a thickened anterior (proximal) end which, in my large specimens, forms a marked eminence on the anterior end of the entire bone, the eminence being round in outline and having a flat summit. This flat surface is presented toward a similar surface on its fellow of the opposite side, and is bound to that fellow by a short strong ligament. The dorso-posterior corner of the eminence is in contact with the ventro-anterior corner of the rostral. The bone has ascending and articular processes, more or less fused to form a single large process which rises from the membrane component of the bone. The ascending process is shorter and stouter than in Scorpaena, being but little if any longer than the articular process. It lies upon and is firmly bound to the dorsal surface of the rostral, and between it and its fellow of the opposite side there is a deep V-shaped groove, as in Scorpaena. The articular process gives articulation to the maxillary in exactly the same manner that the corresponding process does in Scorpaena, and here, as there, a pad of semi-cartilaginous tissue lies between the articulating surfaces.

The MAXILLARY has an anterior, articular end, strictly comparable to that of Scorpaena, but the middle portion of the shelf-like ligamentary process of that fish is wanting here, as it is in Cottus. This is doubtless due to the fact that, in both Trigla and Cottus, the anterior end of the lachrymal has not the strong attachment to the maxillary that it has in Scorpaena, the lachrymal, in Trigla, projecting above and beyond the maxillary without coming into contact with it. The maxillary process of the palatine articulates with the dorsal surface of the maxillary, as in Scorpaena, the articulation taking place in a depression, which lies in the angle between the ascending process and the shank of the bone. The extreme proximal end of the bone lies along and is bound by tissue to the ventral surface of the rostral. The bone articulates by the dorso-posterior portion of its ascending process, and through the intermediation of a pad of fibrous or semi-cartilaginous tissue, with the lateral surface of the eminence, already described, on the dorsal surface of the ascending process of the vomer. On the internal surface of the bone, beginning opposite its ascending process and extending distally somewhat beyond it, there is a flat shelf-like ridge, the distal end of which is enlarged and gives insertion to a large tendon of the superficial division, A_1, of the adductor mandibulae muscle, that tendon having its insertion, in Scorpaena, in a slight depression in this same part of the maxillary. The maxillo-mandibular ligament has its insertion, together with a small tendon of the superficial division, A_1, of the adductor mandibulae, and also with a tendon of the deeper division, A_2A_3, of that muscle, on a ridge-like eminence on the dorsal surface of the maxillary, this eminence thus replacing the distal end of the ligamentary process of Scorpaena. The ethmo-maxillary ligament is inserted on the base, or sometimes even near the summit of the ascending process.

The cartilaginous ROSTRAL is broader than in Scorpaena, and the median portion of its posterior half, alone, has sliding contact with the dorsal surface of the snout. This surface of contact is relatively wide and is usually slightly concave, but in some specimens it is flat or even slightly convex, conforming in this to the much flattened dorsal surface of the snout of the fish. The dorsal surface of the cartilage is conical, or pyramidal, sloping upward from all sides toward a central point. The ascending processes of the premaxillaries rest upon the anterior half only of this surface, the posterior portion being exposed. Immediately dorso-posterior to the ascending processes of the premaxillaries, on the central point of the cartilage, there is a mass of tough fibrous tissue from which, on either side, the rostro-palatine ligament has its origin. These ligaments do not form a continuous band crossing the middle line of the head, as in Scorpaena, and they are not, as in that fish, in contact

with the premaxillary. Each ligament is inserted, as in Scorpaena, on the base of the maxillary process of the palatine. In one of four specimens examined, there was, in the middle line, between the two ligaments, a small disk of bone on which the ligaments had their origins; and it would seem as if this bone might be the rostral bone of Sagemehl's descriptions, a bone which that author considered as an ossification of the rostral cartilage.

The FRONTAL has a ventral flange, but it is but slightly developed. The anterior end of the bone overlaps externally the bounding edges of the mesethmoid and ectethmoid, those bones separating the frontal, by a considerable interval, from the hind end of the nasal. Mesially the frontal suturates, in the mid-dorsal line, with its fellow of the opposite side. Its hind edge is relatively straight, forms a right angle with its mesial edge, and, extending from the middle line of the head to the mesial edge of the pterotic, suturates its full length with the anterior edge of the parieto-extrascapular. The posterior portion of the short postorbital portion of the lateral edge of the bone suturates with the pterotic, its anterior portion touching a corner of the postfrontal and also abutting against a raised portion of the sphenotic that comes to the level of the dorsal surface of the skull and has surface markings similar to those of the dermal bones. This little raised portion of the sphenotic forms the dorso-lateral corner of the postorbital process of the skull, and between its hind edge and the lateral portion of the anterior edge of the pterotic there is a little notch which is occupied by the small postfrontal bone. The postero-mesial corner of the raised portion of the sphenotic arches toward and, in medium-sized specimens, touches, or almost touches, the anterior corner of the dermal portion of the pterotic, a circular passage being left between the two bones, which transmits that primary tube of the supraorbital latero-sensory canal that anastomoses with the main infraorbital canal as that canal passes from the postfrontal into the pterotic. The frontal is traversed by the supraorbital latero-sensory canal and lodges five sense organs of that line, the fourth and fifth organs of the line lying relatively close together, without intervening primary tube, as in Scorpaena.

The PARIETO-EXTRASCAPULAR is a flat bone, and is traversed, near its hind edge, by the supratemporal latero-sensory canal, that canal uniting with its fellow in the mid-dorsal line to form a complete cross-commissure. The bone suturates, in the mid-dorsal line, with its fellow of the opposite side, completely covering the supraoccipital excepting only a narrow hind edge of that bone, and, slightly anterior to that edge, a small, variable and irregular median portion of the dorsal limb of the bone. Anteriorly the bone suturates with the frontal. Laterally it suturates with the pterotic, lateral extrascapular and suprascapular, not appreciably overlapping, in most of my specimens, the epiotic process of the latter bone. On its dorsal surface, near the middle of the bone, there is, in my medium-sized specimens, a slightly raised and granulated ridge, longitudinal in position, which apparently corresponds to the ridge that forms the lateral boundary of the subquadrangular groove on the vertex of Scorpaena. The section of the supratemporal latero-sensory commissure that is enclosed in the bone lodges one sense organ of that canal.

The POSTFRONTAL is a small bone that lies in the angular interval between the pterotic and the raised, dermal-like portion of the sphenotic. Its mesial corner approaches closely, or even touches, between those two bones, the lateral edge of the frontal. It is traversed by the infraorbital latero-sensory canal and lodges one organ of that line, innervated by a branch of the oticus lateralis.

The LATERAL EXTRASCAPULAR is a small subcircular bone that lies in the space between the pterotic, parieto-extrascapular and suprascapular bones, with all of which bones it is firmly

united. It forms part of the roof of the temporal fossa, and is traversed by the main infraorbital and supratemporal latero-sensory canals, lodging one organ of each of those lines.

The SUPRASCAPULAR is bounded anteriorly by, and firmly united with, the lateral extrascapular and the parieto-extrascapular, and forms part of the hind edge of the casque-like dorsal surface of the skull. It has opisthotic and epiotic processes which are attached, respectively, and in the usual manner, to processes of the opisthotic and epiotic bones. Immediately posterior to the base of the opisthotic process there is a large articular facet, the lateral edge of which is slightly differentiated as an articular eminence, this being more evident in small than in large specimens. The two surfaces give articulation to articular surfaces on the dorsal end of the supraclavicular. Immediately posterior to the articular eminence is the posterior opening of the section of latero-sensory canal enclosed in the bone, this section of canal lodging one sense organ of the main infraorbital line. The bone extends some distance beyond the opening of the canal and terminates in a stout point.

The SUPRACLAVICULAR has a small dorsal end, the anterior corner of which is entirely occupied by a large condylar eminence. Immediately postero-lateral to this eminence, there is a small flat or slightly concave articular surface. These two surfaces articulate with the two articular surfaces on the ventral surface of the suprascapular, the supraclavicular lying beneath the suprascapular and not extending back to the hind end of that bone. Immediately posterior to these articular surfaces the posterior half of the dorsal edge of the bone is traversed by the main latero-sensory canal, the section of canal lodging one sense organ of the line. The ventral end of the bone is slightly expanded, and has a large depression on its inner surface. The anterior and posterior edges of this depression, and also the thin ventral edge of the bone, rest upon and are firmly bound by tissues to the dorsal end of the clavicle, the supraclavicular fitting into a depression on the outer surface of the latter bone. This depression in the clavicle surrounds a deep notch in the edge of that bone, this notch corresponding to the notch shown in my figures of the clavicle of Scomber. The depressed region on the inner surface of the supraclavicular overlies this notch in the clavicle, and the occipito-supraclavicular ligament, passing through the notch, has its insertion in the depression on the supraclavicular. Nothing whatever in the arrangement of the parts is abnormal, as compared with Scorpaena, nor is the supraclavicular (postero-temporal) at all crowded out of its normal place and relation to the other bones, as stated by Gill ('88) and by Jordan and Evermann ('98). The bone is simply inclined backward more than in Scorpaena, its dorsal end is smaller, and the prolonged hind end of the suprascapular projects backward considerably beyond it.

The PARASPHENOID is large, with expanded anterior and posterior portions that are connected by a short but relatively wide intervening portion. The ventral surface of the anterior portion is deeply grooved to receive the vomer, the dorsal surface of this portion presenting a correspondingly wide, low and rounded, median longitudinal ridge. On the dorsal surface of the posterior portion of the bone there is a wide raised median portion, the deeply grooved lateral edge of which receives, on either side, the cartilaginous ventral edge of the proötic; the raised portion thus not only closing the hypophysial fenestra but also forming, on either side of that fenestra, a relatively considerable part of the floor of the myodome. The ascending process of the bone, on either side, is represented by a short, slender and sharply pointed dorsal extension of the thickened anterior edge of the expanded posterior portion of the bone, and so unimportant is it that the process seems, at first sight,

to be wholly wanting. A deep and narrow incisure, which separates the process from the almost equally tall posterior portion of the bone, transmits the internal carotid artery. From this incisure a groove runs upward on the outer surface of the proötic, toward the facialis opening of the trigemino-facialis chamber, and lodges the internal carotid artery. Ventral to the internal carotid foramen this groove is continued on the outer surface of the parasphenoid, but there simply marks the posterior limit of the surface of insertion of the adductor arcus palatini. The infrapharyngobranchial of the first arch has its attachment to the skull anterior to the groove, in the immediate neighbourhood of the internal carotid foramen.

Between, or slightly anterior to the anterior edges of the ascending processes of the parasphenoid there is, in the middle line of the dorsal surface of the bone, a pronounced and sharply pointed process, directed dorso-posteriorly. The anterior edge of this process is grooved, is presented dorso-anteriorly, and lodges the ventral edge of the posterior portion of the cartilaginous interorbital septum and, dorso-posterior to that cartilage, and continuous with it, the ventral end of the pedicle of the basisphenoid. On the ventral surface of the bone, slightly anterior to this little process, there is, on either side, a slight process, or ledge directed laterally, which thus has approximately the position of the well developed process of Osteoglossum.

The ORBITS are roofed by the ectethmoids and frontals, and are separated from each other by an interorbital septum, the anterior portion of this septum being of cartilage, while its posterior portion is of membrane. The extreme anterior end of the septum is perforated by an opening which puts the orbits in communication with each other, this opening forming the median part of the anterior eye-muscle canal. The hind wall of the orbit is formed by the alisphenoid, basisphenoid, proötic and sphenotic, and is slightly reëntrant in its lateral portion, this being due to the projecting anterior edge of the lateral surface of the brain case. The ventral flange of the frontal being but slightly developed, the orbital opening of the brain case is, in consequence, large and somewhat rectangular in shape.

The MYODOME has proötic and basioccipital portions, the latter extending only about one half the length of the basioccipital, and opening posteriorly on the ventral surface of that bone by a small opening only. The orbital opening of the myodome is large and inclines strongly downward and forward, while the roof of the proötic portion, or body of the myodome inclines strongly downward and backward. This is due to a deepening of the orbits, posteriorly, and a correlated and marked tilting upward of the mesial processes of the proötics, this giving to the myodome the appearance of a large and deep recess at the hind end of the orbits.

There is no ORBITOSPHENOID.

The ALISPHENOID is bounded by the sphenotic, the frontal, and the prepituitary portion of the mesial process of the proötic, the basisphenoid not coming into bounding contact with it. The antero-mesial edge of the bone is slightly concave, and bounds the orbital opening of the brain case. This edge of the bone forms a continuous line with the anterior edge of the mesial process of the proötic, and the adjoining edges of the two bones are cut away to form a rounded incisure which transmits the nervus trochlearis. Dorsal to this incisure, in the anterior edge of the alisphenoid, there is another incisure, often closed to form a small foramen, which transmits the cerebral branch of the orbito-nasal vein. Near the center of the bone there is a larger foramen which transmits that branch of the ophthalmicus lateralis that supplies the small latero-sensory organ in the terminal

tube of the supraorbital canal. This nerve, as in Scorpaena, perforates the alisphenoid, then runs upward along the inner wall of the skull, traverses the lateral fontanelle, and, perforating the frontal, reaches its organ. As in Scorpaena, the nerve is accompanied, as it traverses its foramen, by branches of the external carotid artery and the vessel x.

On the external surface of the bone, near its ventral edge, there is a short and slight ridge which is continued downward onto the external, ventro-anterior surface of the mesial process of the proötic. Toward this ridge a small process projects dorsally from that part of the proötic that forms the anterior edge of the lateral surface of the brain case, this process being of very variable length, and the process and the ridge above it being connected by fibrous tissues. That part of the ridge that lies on the alisphenoid represents a slight remnant of the parasphenoid leg of that bone, the part that lies on the proötic here replacing a part of that process of the parasphenoid that, in Cottus, comes into contact with the alisphenoid.

On the internal surface of the alisphenoid, at about its antero-dorsal quarter, there is a brace-like thickening of the bone, which is the greatly developed homologue of the small ridge described on the internal surface of the alisphenoid of Scorpaena. The flat dorsal surface of the brace is cartilaginous in places, reaches the level of the dorsal edge of the bone, and abuts against the ventral surface of the frontal; the hind edge of this surface of the brace almost reaching the anterior edge of the supraoccipital. The lateral edge of the dorsal surface of the brace forms the mesial boundary of the anterior half of the lateral cranial fontanelle, its mesial edge being in synchondrosis with a large, median postepiphysial interspace of cartilage which extends forward from the anterior edge of the supraoccipital. The anterior edge of this postepiphysial interspace of cartilage is slightly concave, and extends from the anterior edge of the alisphenoid of one side to that of the other side. From the antero-lateral corner of the cartilage, a band of cartilage runs postero-laterally along the dorsal edge of the plate-like body of the alisphenoid, the postero-lateral end of the band being continuous with a band of cartilage that runs backward along the mesial edges of the sphenotic and pterotic and forms the lateral boundary of the lateral cranial fontanelle. In Trigla gurnardus, a specimen of which was used for the figure showing a dorsal view of the chondrocranium, there was a deep bay in the anterior edge of the postepiphysial cartilage, much larger and deeper than that found in the specimens of Trigla hirundo that were examined.

The BASISPHENOID has a long pedicle which is directed downward and forward at an angle of from 30° to 45°, the two wings of the body of the bone being directed laterally and slightly upward. The bone does not come into bounding contact with the alisphenoid. Along the dorsal surface of the body of the bone, on either side, the optic nerve pierces the membrane that closes the orbital opening of the brain case and enters the orbit. Slightly dorsal to the optic nerve, the nervus olfactorius pierces the same membrane, and from there runs forward along the lateral surface of the interorbital septum, lying wholly free in the orbit. In the hind edge of the body of the bone, in my largest specimen, there is a median and imperfectly closed foramen which unquestionably transmits the median encephalic artery formed by the fusion of the internal carotid arteries of opposite sides of the head.

The LATERAL SURFACE OF THE BRAIN CASE is relatively flat and narrow, and its anterior edge has a pronounced reëntrant angle, at about the middle of its height. That part of this edge that lies ventral to the point of the angle inclines forward and downward and is formed by a thin plate of bone which, in its dorsal portion, projects forward considerably beyond the adjoining portion

of the orbital surface of the brain case. The postero-ventral portion of the orbit is thus here bounded laterally by bone, this part of the orbit leading into and being continuous with the myodome.

The PROÖTIC forms the middle three-fifths of the anterior edge of the brain case, the dorsal fifth being formed by the sphenotic, and the ventral fifth by the short ascending process of the parasphenoid. At the middle of the entire edge there is a large foramen which perforates a thin plate-like portion of the edge and leads directly into a small recess which lies on the orbital surface of the proötic immediately dorso-lateral to the orbital opening of the myodome. This recess is the imperfectly enclosed trigemino-facialis chamber, and the large foramen that opens from it onto the lateral surface of the brain case is the facialis opening of that chamber. The lateral wall of the chamber is reduced to the slender column of bone that forms the anterior boundary of the facialis opening. Anterior to this column of bone there is, on the projecting plate-like edge of the proötic, a process of variable length and shape, already referred to, which projects upward toward the slight ridge on the orbital surface of the alisphenoid. This latter ridge, as already stated, represents the parasphenoid leg of the alisphenoid, the process of the proötic being a proötic outgrowth which has invaded the alisphenoid membrane, there replacing, in this fish, the parasphenoid outgrowth found in Cottus. Across the dorsal surface of this process of the proötic, or between it and the column that bounds the anterior edge of the facialis opening, this depending on the shape of the process, the truncus trigeminus has its exit from the chamber.

The mesial wall of the trigemino-facialis chamber is perforated by three or four foramina; two of them being large and the other one or two considerably smaller. Where there are four foramina, one of the large ones transmits the root of the trigeminus together with the buccalis lateralis, the other large one transmitting the motor root of the facialis together with the lateralis facialis and all of the communis fibers of the trigemino-facialis complex; the two small foramina transmitting, one, the ophthalmicus lateralis and the other the ciliaris profundi with the encephalic vein. Where there are but three foramina, the ophthalmicus lateralis issues with the trigeminus and buccalis lateralis through a partly separate portion of a single large foramen, the profundus and facialis always issuing through independent foramina. The palatinus facialis issues through the facialis foramen, then turns mesially along the floor of the trigemino-facialis chamber, and so enters the myodome. It is not here enclosed in a separate canal. Directly mesial to the profundus foramen, the prepituitary portion of the mesial process of the proötic is perforated by the oculomotorius, that nerve in 5 cm and 6 cm specimens of Lepidotrigla, separating into its superior and inferior divisions before reaching its foramen. The postpituitary portion of the mesial process is, in large specimens, either perforated or notched by a foramen that transmits the abducens, that nerve passing directly from the cranial cavity into the myodome.

In the ventral edge of the proötic, is the internal carotid incisure. Posterior to that incisure the ventral edge of the bone is capped its full length with cartilage and abuts against the parasphenoid in the deep groove along the lateral surface of the median longitudinal ridge on the dorsal surface of the bone.

On the internal surface of the proötic there is, as in Scorpaena, a trigemino-facialis recess, and this recess lodges, as in Scorpaena, the communis, lateralis and profundus ganglia.

On the lateral surface of the dorsal portion of the proötic there is a fossa, and immediately anterior to the fossa a brace-like process, the process and fossa giving insertion to the two internal

and first four external levators of the branchial arches, as in Scorpaena. Between the thick dorsal end of this brace-like process and the adjoining portion of the sphenotic, there is a deep socket-like articular facet for the anterior articular head of the hyomandibular. Slightly posterior to this facet, on the lateral surface of the pterotic, is the oval and shallower facet for the posterior articular head of the hyomandibular. Immediately dorsal to the line between these two articular facets, there is a pit-like depression on the adjoining edges of the pterotic and sphenotic, the depression lying immediately beneath the postfrontal. It is the dilatator fossa, the dilatator operculi arising partly in this fossa and partly on the external surface of the dorsal end of the hyomandibular, as in Scorpaena. Immediately anterior to the dilatator fossa, and slightly dorsal to the anterior articular facet for the hyomandibular, on the slightly concave dorso-lateral corner of the sphenotic, the levator arcus palatini has its origin. A canal for the ramus oticus traverses the sphenotic, entering that bone on its orbital surface.

At about the middle of the lateral surface of the brain case, and near the hind edge of the proötic, there is a small foramen which transmits the root of the nervus glossopharyngeus. Dorsal to the line between this foramen and the vagus foramen there is a triangular subtemporal depression which, as in Scorpaena, gives origin to the adductor hyomandibularis and adductor operculi, and also, immediately posterior to the latter muscle, to the external levators of the fourth and fifth branchial arches. The levator operculi has its origin along the dorsal edge of the lateral surface of the skull, as in Scorpaena.

The PTEROTIC contains two latero-sensory organs innervated by the oticus lateralis, and one post-preopercular organ innervated by the supratemporal branch of the lineae lateralis vagi. The two organs innervated by the oticus were found in both of the two specimens examined, one being an adult Trigla and the other a small Lepidotrigla. These two organs lie relatively close together and there is no indication whatever of a primary tube between them. They accordingly quite probably represent the two independent otico-squamosal organs of Amia, here in process of concentration into a single organ, exactly as already set forth for the fourth and fifth supraorbital organs of this fish, of Sebastes and of Scorpaena. Otherwise the pterotic of Trigla offers no apparent difference from the bone in Scorpaena, excepting in that its posterior process is less extensive. The dorsal portion of the hind edge of the lateral surface of the brain case projects latero-posteriorly as a tall, thin ridge of bone, but this ridge is formed mainly by portions of the exoccipital and opisthotic, its dorsal edge only being formed by the posterior process of the pterotic.

The OPISTHOTIC forms an actual part of the bounding wall of the posterior semicircular canal, a part of that part of the pterotic region of the chondrocranium that, in Scorpaena, bounds this canal having been suppressed in Trigla, and a large opening, leading directly into the canal, being exposed when the opisthotic is removed. The opisthotic does not, however, seem to have anywhere acquired primary relations to the skull, the underlying cartilage apparently having simply been resorbed.

The EXOCCIPITAL is perforated by two foramina, one for the vagus and the other for the occipital nerves, these two foramina being separated by the base of the condylar process that gives articulation to the anterior articular process of the first vertebra. In Scorpaena both of these foramina lie antero-lateral to the base of the condylar process, separated by a slight ridge which is a ventral prolongation of the postero-lateral angle of the skull. Dorsal to the foramen for the occipital nerves

there is, in Trigla, a slight projecting ledge, this being much more marked in my small specimens than in the large one used for the drawings. The hind edge of this ledge, in the small specimens, projects posteriorly as a sharp angle, and beneath this part of the ledge the dorsal surface of the condylar process of the exoccipital gives support to the lateral portion of the base of the first vertebral arch. The mesial and larger portion of the base of the arch rests upon a portion of the dorsal surface of the articular process of the independent centrum of the first vertebra, this surface of contact lying postero-mesial to and contiguous with the supporting surface on the exoccipital. The arch does not come into contact with the basioccipital.

The mesial process of the exoccipital, so well developed in Scorpaena, is but slightly developed in Trigla. It is directed ventro-mesially, at about 45°, its ventral end, which is widely separated from its fellow of the opposite side, resting upon a small process-like portion of the dorsal surface of the basioccipital, this part of the basioccipital forming the mesial wall of the hind end of the saccular groove.

The BASIOCCIPITAL is broad and relatively short. Its anterior end is deeply and widely excavated by the hind end of the myodome, a narrow, longitudinal, and slit-like opening leading from this groove onto the outer surface of the bone. That part of the basioccipital that forms the roof of the myodome is flat and inclines downward and backward almost at an angle of 45°, the wide and relatively shallow saccular groove of either side being, in consequence, pushed on to what appears as a lateral portion of the cerebral surface of the bone, and being also tilted upward at a considerable angle. The hind end of the saccular groove forms a recess in the basioccipital, and between the recesses of opposite sides there is, on the dorsal surface of the bone, a large median pit which is the cavum sinus imparis. Posterior to this pit, and at a considerably higher level, a short portion of the dorsal surface of the bone forms the floor of the foramen magnum. The hind end of the bone is irregular, the appearance being that of the ordinary vertebra-like hind end of this bone, with the dorso-lateral corners deeply cut away. This leaves a depressed surface on either side of the dorsal portion of the hind end of the bone, and this depression receives and gives support to the anterior articular process of the first vertebra. On the lateral surface of the hind end of the bone there is a flattened surface which gives origin to the occipito-supraclavicular ligament.

The centrum of the FIRST FREE VERTEBRA is an irregular disk of bone without attached dorsal arch. The posterior surface of the disk has the usual concave vertebral depression, while on its anterior surface there is simply a flat or slightly concave median portion. From the dorso-lateral portion of the centrum, on either side, a stout process projects antero-laterally, rests upon the basi-occipital in the depressed region at the dorso-lateral corner of its hind end, and there articulates with the condylar process of the exoccipital. The bases of these two anterior articular processes of the first centrum are joined by a stout web of bone which forms a shelf projecting forward from the dorsal edge of the centrum, thus making the dorsal surface of the centrum much wider, antero-posteriorly, than its ventral surface. On either side of the dorsal surface of the centrum there is a depression which receives the ventral surface of an anterior process of the second vertebra, this latter process bearing and being fused with the base of the preforaminal portion of the arch of its vertebra. This process of the second vertebra, in small specimens, but not in the large one used for the figures, extends, in its lateral portion, almost to the anterior end of the corresponding process of the first vertebra, the free arch of this latter vertebra thus appearing, in lateral views, to rest almost

entirely upon the condylar process of the exoccipital. This appearance is however deceptive, for, as stated when describing the exoccipital, the postero-mesial and larger portion of the base of the arch of the first vertebra rests upon the mesial portion of the dorsal surface of the anterior process of its own centrum. The dorsal arch of the first vertebra is represented by two bones, one on either side, which touch in the mid-dorsal line above the spinal cord but are not there ankylosed with each other. On the lateral surface of each half of the arch, there is a deep pit which gives insertion to the most anterior rib. Ventral to this pit, the base of the arch is perforated by a foramen which transmits the first spinal nerve. The base of the second arch is similarly pierced by a large foramen which transmits the second spinal nerve; and dorsal to this foramen there is, on the lateral surface of the arch, a large depression which gives insertion to the second rib. The two halves of this arch of the second vertebra meet and ankylose in the mid-dorsal line above the spinal canal, but, like the arch of the first vertebra, this arch does not extend dorsally beyond the point of ankylosis; these two arches being much shorter than the next following ones.

The POSTERIOR SURFACE OF THE SKULL of Trigla differs somewhat from that of Scorpaena. It slopes rapidly downward nearly to the level of the large foramen magnum, and then curves rather abruptly backward to form the nearly straight and horizontal dorsal edge of that foramen. Each half of the surface is separated into two portions by the nearly vertical epiotic ridge, and across the dorsal portion of the mesial one of these two portions there is a large and rounded transverse ridge. This ridge is formed entirely by the epiotic and supraoccipital, and apparently corresponds to what I have described, in Scorpaena, as the hind edge of the primary skull; this being more evident in Trigla gurnardus than in Trigla hirundo. Such being the case, the slightly depressed region, on either side, between the transverse ridge and the hind edge of the secondary skull would correspond to the supratemporal pocket of Scorpaena.

The TEMPORAL FOSSA is relatively small, as compared with Scorpaena. Its posterior opening is bounded mesially and laterally, respectively, by the epiotic ridge and the opisthotic process of the suprascapular, the latter process lying in a nearly vertical longitudinal plane, instead of, as in Scorpaena, in the inclined plane of the lateral surface of the skull. Because of this position of the opisthotic process of the suprascapular, there is a large opening leading into the fossa from the lateral surface of the skull. In the mesial wall of the fossa there is a large but low preëpiotic fossa, this fossa being simply a pocket-like diverticulum of the temporal fossa. The roof of the fossa is formed mainly by the suprascapular and lateral extrascapular, but partly also by projecting edges of the epiotic, pterotic and parieto-extrascapular.

The SUPRAOCCIPITAL has a large postero-ventral limb which forms a large median portion of the posterior surface of the skull. A small median ridge near the dorsal end of this limb of the bone represents the much reduced spina occipitalis. The dorsal limb of the bone is completely covered by the overlying parieto-extrascapulars excepting only a narrow hind edge and a small and variable portion of its dorsal surface which lies slightly anterior to that hind edge. The anterior edge of this limb of the bone bounds and is continuous with the hind edge of the post-epiphysial cartilage, its lateral edges bounding, on either side, the posterior portion of the lateral cranial fontanelle.

The EPIOTIC has a stout suprascapular process, this process and also the dorsal surface of the bone itself, being entirely covered, dorsally, by overlying portions of the suprascapular and parieto-extrascapular; the epiotic thus being wholly excluded from the dorsal surface of the skull.

2. INFRAORBITAL BONES.

The infraorbital bones are all marked with granulated surface striae, and there were, in the two large specimens, but three of these bones. In all of the several smaller specimens there were four bones, the first and second bones of the series, found fused in the larger specimens, here being separate and distinct. Trigla hirundo thus differs in the number of its infraorbital bones from any of the combinations given by Günther in his descriptions of the fishes of the family, that author giving five of these bones in Trigla pini, two in Trigla gurnardus and six in Trigla lyra. But these numbers, given by Günther, may not be correct for all ages of the fishes mentioned, for in two specimens of T. gurnardus sent me by Dr. Allen, of Plymouth, England, there were five infraorbital bones instead of two as stated by Günther.

The anterior bone of the series, in the smaller specimens of Trigla hirundo, is the lachrymal, and is a large and somewhat triangular bone, the anterior end of which curves strongly mesially and so gives to the bone a concave internal and convex external surface. The curved anterior end of the bone is considerably thickened, but its ventro-anterior edge is simply coarsely serrated and not furnished with prominent spines, as Günther states in his descriptions of this fish. In this the fish resembles Günther's descriptions of Trigla gurnardus rather than T. hirundo, its colour and other characteristics however identifying it as the latter. The thickening of this anterior end of the lachrymal is apparently due to accretions to its inner surface, and this surface of this part of the bone is partly covered with surface striae or granulations. From the hind end of this thickened portion, two ridges run backward on the internal surface of the bone; one along the ventral edge of the bone, and the other near and parallel to its dorso-anterior edge; both ridges being prolonged beyond the body of the bone as relatively long and slender processes. The dorso-anterior edge of the bone, dorso-anterior to the second one of the two ridges just above mentioned, is thin, and its anterior and posterior thirds rest upon and are firmly bound to portions of the dorsal edge of the palatine. Between these two regions of contact with the palatine, the lachrymal is cut away by a long oval incisure which is bridged by the underlying palatine. An opening is thus left between the lachrymal and the palatine, this opening lying directly opposite the slit-like opening of the nasal pit and lodging the lateral half of the nasal sac. That part of this edge of the lachrymal that lies anterior to this nasal incisure rests upon the maxillary process of the palatine, and there has a flat, pointed, and more or less developed process which, as stated when describing the nasal, gives sliding articulation to the antero-lateral corner of that bone. That part of the edge of the lachrymal that lies posterior to the nasal incisure inclines mesially and rests upon those portions of the palatine bone and cartilage that form the posterior ethmoid process. On the external surface of this part of this edge of the lachrymal there is a small groove, parallel to the edge and extending posteriorly to the base of the slender and related dorso-posterior process of the bone. At its anterior end this groove is bounded mesially by a part of the palatine, and here, and throughout the larger part of its length, the groove is, in large specimens, filled with a line of tough fibrous tissue which binds the bone to the summit of the articular ridge on the ventral surface of the ectethmoid. There is thus articulation here between these two structures, but there are no regular articular surfaces. The articulation, such as it is, represents the combined ethmo-lachrymal and posterior ethmo-palatine articulations. Posterior to this articular portion, the dorso-posterior process of the lachrymal projects backward as a free and slender process which lies against and is closely attached to the larger one of the two ethmo-palatine ligaments already described. This

ligament, running forward from its point of origin on the ectethmoid, has its insertion on the palatine cartilage, the process of the lachrymal thus being developed in supporting relation to it. The second ethmo-palatine ligament is, as already stated, a slender and delicate one that arises from the ventral surface of the ectethmoid. Running forward from there, parallel to but at a certain distance from the larger ligament, it also is inserted on the hind end of the palatine cartilage.

The lachrymal is traversed by the infraorbital latero-sensory canal and lodges three organs of that line.

The second infraorbital bone is a large and almost parallelogrammic bone. The striae on its outer surface radiate mainly from a point that lies near the ventral quarter of the bone directly superficial to the latero-sensory canal that traverses the bone, but partly also from a second point that lies slightly antero-ventral to the first one, and also directly superficial to a portion of the latero-sensory canal; these two points apparently representing the centers of ossification of two bones, here fused but found separate in a 63 mm specimen of Lepidotrigla examined in serial sections.[1])

In the hind edge of the bone, at about its ventral third, there is a more or less pronounced angular incisure. Dorsal to this incisure the hind edge of the bone abuts against the anterior edge of the preopercular, overlapping it but slightly at any place. Ventral to the incisure, the bone also abuts against the anterior edge of the preopercular, but it there also rests upon the lateral edge of the posterior process of the quadrate, the attachment to this latter bone being particularly strong, much stronger than to the preopercular. The point of the incisure lies in the line, anteriorly produced, of the dorsal and largest preopercular spine, and fits against a pointed portion of the anterior surface of the outer edge of the preopercular. From the point of the incisure, and extending backward across the outer surface of the preopercular to the base of its dorsal spine, there is a slight but distinctly evident tuberculated ridge, this ridge being also continued forward across the second infraorbital bone. Ventral to the ridge, both the preopercular and second infraorbital incline slightly downward and inward, the ridge thus separating two somewhat inclined surfaces. In my large specimens this ridge is but slightly indicated, while in the small ones it is quite pronounced.

The infraorbital latero-sensory canal enters the second infraorbital bone on its outer surface near the middle point of its dorsal edge, this point lying at the anterior edge of the orbit. Posterior to this point there is a depressed region on the outer surface of the dorsal edge of the bone, the depression lodging the ventral portions of the third and fourth infraorbital bones. From the point where the canal enters the outer surface of the second infraorbital bone it runs downward and forward in the line of the striae on the outer surface of the bone until it reaches the principal point from which those striae radiate. There it sends a long primary tube backward nearly to the hind edge of the bone, and itself turns gradually forward to leave the bone at its anterior end and enter the lachrymal. The primary tubes that arise from the canal as it traverses the bone all open on its outer surface ventral to the longitudinal striated ridge just above described. The bone lodges four organs of the infraorbital line.

The third and fourth infraorbital bones are relatively small. The third bone has the shape of an elongated rectangle, occupies the larger part of the depressed region along the dorsal edge of the second infraorbital bone, and forms the ventral edge of the orbit. The fourth bone is somewhat

[1]) Since the completion of the manuscript these two bones have also been found separate in a medium-sized specimen of Trigla hirundo.

triangular, with curved edges. Its ventral edge fits onto the outer surface of the second infraorbital, its hind edge overlapping and resting upon the anterior edge of the preopercular, and extending nearly to its dorsal end. Its concave anterior edge forms the posterior boundary of the orbit. Its dorsal end does not quite reach the lateral edge of the postfrontal. These two bones are traversed by the main infraorbital canal, and each lodges one organ of that line.

3. SUSPENSORIAL APPARATUS AND MANDIBLE.

The QUADRATE has the usual shape, with its ventral corner enlarged to form the articular head for the mandible. Its antero-ventral edge is bevelled, and fits into the grooved hind edge of the ventral limb of the ectopterygoid. Its ventro-posterior edge is greatly thickened, is prolonged dorso-posteriorly in a short sharp posterior process, and between this process and the body of the bone, on the internal surface of the element, there is a large symplectic groove. The ventro-posterior surface of the posterior process is grooved and fits against and is firmly bound to the anterior edge of the ventral end of the preopercular. The lateral surface of the process is raised in a large and tall ridge, the outer surface of which is roughened and gives support to, and is firmly bound to, the ventro-posterior corner of the second infraorbital bone. The dorso-posterior end of this raised portion fits into a small notch in the anterior edge of the preopercular. Between this raised portion of the process and the external surface of the body of the quadrate, there is a large depression which seems to have no special morphological significance.

The METAPTERYGOID has its dorso-anterior edge bent slightly inward, and has lateral and mesial flanges along its hind edge. The mesial flange is a small one excepting at its dorsal end where it is prolonged into a process which meets, or almost meets a flat process that projects antero-ventrally from the anterior edge of the thin web of bone that fills the space between the anterior articular arm of the hyomandibular and the shank of that bone, and is bound to that process by fibrous tissues. Ventral to this process-like portion, the hind edge of the mesial flange is connected by a wide sheet of membrane with the shank of the hyomandibular. The lateral flange projects postero-laterally at a slight angle to the body of the bone, and reaches, or overlaps slightly, and is attached to the outer surface of the ventral end of the shank of the hyomandibular. The ventral corner of this lateral flange approaches, or may even reach and rest upon the outer surface of the cartilaginous interspace between the hyomandibular and symplectic; and there is, in the corner of the flange, an incisure which, with the adjoining cartilage and the hyomandibular, forms a foramen which transmits the arteria hyoidea.

The ECTOPTERYGOID has the usual two limbs lying at an obtuse angle to each other, the dorso-anterior limb being a large plate the dorsal edge of which is grooved. This groove lodges the ventral edge of the anterior end of the entopterygoid, and also that part of the palatine bone and cartilage that forms the posterior ethmoid process of the apparatus, the lateral edge of the groove being a tall plate which lines the lateral surface of the palatine cartilage and may even project dorso-posteriorly slightly beyond the cartilage. The anterior edge of this part of the ectopterygoid is somewhat jagged, and suturates with the hind edge of the ventral flange of the palatine. The ventro-posterior limb of the bone is grooved on its posterior surface and fits against the antero-ventral edge of the quadrate.

The ENTOPTERYGOID is small, and its ventral half lies closely against the inner surface of a part of the cartilage of the apparatus that lies between the metapterygoid and the ectopterygoid, along the dorsal edge of the quadrate. The dorsal half of the bone projects beyond the cartilage, is concave on its outer and convex on its inner surface, and lies against the under surface of and gives insertion to a portion of the adductor arcus palatini. The anterior end of the bone rests in the grooved dorsal edge of the dorsal limb of the ectopterygoid, its posterior end not quite reaching, in small specimens, the anterior end of the metapterygoid.

The PALATINE has a body, a maxillary process, and a stout and large ventral flange of dermal origin. The hind edge of the ventral flange is jagged and suturates with the anterior edge of the dorsal limb of the ectopterygoid. The hind end of the body of the bone is in synchondrosis with the cartilage of the posterior ethmoid process of the apparatus. The maxillary process of the bone curves slightly antero-mesially, is flattened on its dorso-lateral surface, and there rests against and is firmly bound to the internal surface of the dorso-anterior edge of the lachrymal. A small eminence at the base of the maxillary process gives insertion to the rostro-palatine ligament, and immediately posterior to this process there is an obliquely transverse facet which articulates with the anterior palatine process of the ethmoid cartilage. The vomero-palatine ligament is unimportant. The anterior end of the maxillary process of the bone is capped with cartilage and articulates with the dorsal surface of the maxillary, in the angle between the lateral surface of the ascending process and the shank of that bone. The posterior portion of the body of the palatine, and the cartilage that forms the posterior ethmoid process of the apparatus, are firmly bound to the lachrymal, in the manner already described. Between this posterior part of the palatine and the base of its maxillary process, the dorso-lateral surface of the body of the bone is slightly hollowed, this hollow lodging the lateral half of the nasal sac.

The palato-quadrate, as a whole, forms a plate which is slightly concave on its ectal surface, and the two anterior infraorbital bones together form a plate which is slightly concave on its ental surface. These two plates are firmly bound to each other by their anterior edges, while by their posterior edges they are firmly bound to the preopercular and hyomandibular. The two plates together thus form a flat, hollow, trapezoidal structure, open both dorso-mesially and ventro-laterally by large and relatively narrow openings. The space enclosed between the two plates is, in the recent state, almost completely filled by the adductor mandibulae muscle.

The HYOMANDIBULAR is cross-shaped, the arm of the cross lying obliquely to the shank. The summit of the longitudinal ridge on the outer surface of the shank projects forward, and so gives to the anterior surface of the bone a grooved appearance. The dorsal portion of this forwardly projecting ridge gives support, on its lateral surface, to the fourth bone of the infraorbital series. The shank of the bone is traversed by a facialis canal, the ventral opening of that canal lying anterior to the longitudinal ridge. From this canal a single branch canal arises, and running postero-ventrally opens on the outer surface of the bone, near the ventral end of the thin web of bone that fills the space between the opercular process and the ventral portion of the shank of the bone. It transmits a nerve destined to innervate the two dorsal ones of the latero-sensory organs in the preopercular, a single canal thus here replacing the two canals found in Scorpaena. A foramen leads directly from the main canal for the facialis onto the anterior surface of the bone, but it only transmits a blood vessel.

The rod-like SYMPLECTIC lies in the symplectic groove on the internal surface of the quadrate. Between it, and the preopercular and the posterior process of the quadrate there is a large oval opening which transmits the mandibularis externus facialis and the arteria hyoidea. Anterior to the symplectic, between it and the quadrate, there is a small canal which transmits the mandibularis internus facialis.

The arteria hyoidea has a course exactly similar to that in the fishes already described.

The PREOPERCULAR has slightly indicated dorsal and ventral limbs, separated by a low and granulated ridge on the outer surface of the bone. This granulated ridge is much more apparent in small than in large specimens, and terminates posteriorly in a spine which, in small specimens, is sharply pointed. Immediately ventral to this spine there is, in these small specimens, a smaller spine. The dorsal limb of the bone is firmly bound to the hyomandibular, the ventral limb being similarly bound to the posterior process of the quadrate. The anterior edge of the bone gives support and is bound to the hind edge of the second bone of the infraorbital series. The bone is traversed its full length by the preopercular latero-sensory canal, and lodges six organs of the line, the second organ from the dorsal end of the bone being a double one in the one specimen examined.

The OPERCULAR has a large bluntly pointed process which rises from the dorsal edge of the bone immediately dorsal to the articular facet for the hyomandibular, and, projecting dorsally or dorso-anteriorly, nearly reaches the dorso-lateral edge of the skull in the suprascapular region. The inner surface of the process is slightly concave and gives insertion to the adductor operculi, that muscle having a large surface of origin in the subtemporal depression on the lateral surface of the skull, the surface of origin of this muscle lying immediately posterior to that of the adductor hyomandibularis. Immediately posterior to the base of the process, on the inner surface of the dorsal edge of the opercular, the levator operculi has its insertion; this muscle arising from the dorsal margin of the lateral surface of the pterotic in a line beginning immediately posterior to the latero-sensory tube that anastomoses with the dorsal end of the preopercular canal. The dilatator operculi arises partly in the dilatator fossa and partly on the external surface of the dorsal end of the hyomandibular, and is inserted on the anterior edge of the articular facet for the hyomandibular. On the hind edge of the opercular there are two stout spines, the dorsal one curving upward so that its point is directed almost dorsally.

The SUBOPERCULAR is a long, thin and delicate bone. In one of my large specimens the ventral half of this bone was wanting, and the dorsal half was almost completely ankylosed with the hind edge of the opercular.

The INTEROPERCULAR is bound by strong ligamentous tissue, at about the middle of its dorso-anterior edge, to the interhyal and ceratohyal. Its antero-ventral end is bound, by a short strong ligament, to the hind end of the mandible.

The MANDIBLE is relatively longer and more slender than that of Scorpaena. The hind edge of the dentary is V-shaped and receives, in the angle of the V, the long pointed anterior end of the articular, overlapping that bone externally. The dorsal arm of the V reaches the summit of the coronoid process of the articular, and is bound to its internal surface, slightly below the summit of the process. Between this arm of the dentary and the adjoining parts of the articular there is a relatively small and narrow space. The dorsal edge of the dentary is broad and is covered with small villiform teeth; and immediately ventral to this toothed surface there is a deep longitudinal groove

which lodges, as in Scorpaena, a gristly tapering rod-like structure which forms the core of the mandibular labial fold of the fish. The pointed anterior limb of the articular is strongly convex externally and concave internally, and lodges, in its concave internal surface, the rod-like Meckel's cartilage. Posterior to the hind end of Meckel's cartilage the conformation of the rod is continued a short distance by a rounded ridge of bone. There is a short, stout, sharply-pointed coronoid process. The hind edge of the articular facet for the quadrate projects dorso-posteriorly as a stout process which has a sliding articulation on the ventro-posterior surface of the posterior process of the quadrate, as in Scorpaena. The angular is a small bit of bone that caps the hind end of the articular and gives insertion to the strong mandibulo-interopercular ligament. The articular and dentary are both traversed by the mandibular latero-sensory canal, and lodge, respectively, one and four organs of the line.

4. MUSCLES.

The adductor mandibulae muscle of Trigla has anterior and posterior divisions, instead of, as in Scorpaena, superficial and deeper ones. The anterior division forms the anterior third or quarter of the entire muscle and has its origin from a tendinous band that extends along its own dorsal edge and then backward along the dorsal edge of the posterior division of the muscle, to have its origin on the tendinous tissue that forms the anterior edge of the levator arcus palatini. This anterior division of the adductor has its insertion wholly on a tendinous fascia that forms on its internal surface and that terminates anteriorly in two tendons; a stout tendon inserted on the hind end of the ligamentary process of the maxillary, and a less important one inserted on the dorsal surface of the same bone.

The large posterior division of the adductor is partly separated into two portions by the ramus mandibularis trigemini, that nerve traversing the muscle from its inner surface and issuing on its outer surface close to its ventral edge. That part of the muscle that lies anterior to the nerve has its origin on the tendinous band that extends along the dorsal edge of the entire muscle, and that gives origin also to the anterior division of the muscle. It is inserted in part on the tissues that extend from the palato-quadrate apparatus to the maxillary, partly on a tendon that joins the tendon A_2A_3, described below, and partly on a tendon that runs forward and has its insertion on the dorsal surface of the maxillary. This part of this division of the muscle, and the anterior division of the entire muscle, thus together correspond approximately to the superficial portion, A_1, of the muscle of Scorpaena. That part of the muscle of Trigla that lies posterior to the mandibularis trigeminus then corresponds to the muscle A_2A_3 of Scorpaena, and, like that muscle, it arises from the hyomandibular, the preopercular and the outer surface of the palato-quadrate arch, and has its insertion on a tendon that may be called tendon A_2A_3. This tendon is double, having anterior and posterior portions. The anterior portion separates into two parts one of which is continuous with a fascia that forms on the inner surface of A_ω, the other having its insertion on the internal surface of the articular ventral to the hind end of Meckel's cartilage. The posterior portion of the tendon A_2A_3 runs downward along the hind edge of A_ω and has its insertion on the inner surface of the articular dorsal to the hind end of Meckel's cartilage. There is, in Trigla, no tendon running backward, as in Scorpaena, from the tendon A_2A_3 to the inner surface of the quadrate.

The maxillo-mandibular ligament is as in Scorpaena.

The levator arcus palatini is a strong muscle which arises from the small roughened surface on the dorso-lateral corner of the sphenotic. Running almost directly downward it spreads forward and backward, its deeper fibers being immediately inserted on the external surface of the dorso-anterior portion of the hyomandibular. The more superficial fibers of the muscle are inserted in part on the dorsal edge of the lateral flange on the hind edge of the metapterygoid, but in larger part they run downward between that flange and the mesial one and have their insertions on the latter flange, in the membrane that extends from that flange to the anterior edge of the hyomandibular, and also partly on adjoining portions of the hyomandibular.

The adductor arcus palatini is a broad sheet of muscle that has an origin and insertion similar to that of the muscle in Scorpaena. The surface of origin begins posteriorly on the external surface of the narrow bridge of bone that forms the external wall of the trigemino-facialis chamber, runs downward onto the ascending process of the parasphenoid and then, turning forward, extends along the ventro-lateral surface of the parasphenoid nearly to the anterior end of that bone. Running ventro-laterally the fibers of the muscle have their insertion in a long line that begins on the inner surface of the anterior edge of the dorsal portion of the hyomandibular and extends forward along the dorsal edge of the metapterygoid, and then onto the entopterygoid and the palatine cartilage and bone, the line of insertion passing along the dorso-mesial edge of the metapterygoid instead of crossing the internal surface of that bone, as it does in Scorpaena. The small entopterygoid lies upon the internal surface of the ventral edge of the muscle and gives insertion to certain of its fibers.

The adductor hyomandibularis, and the dilatator, adductor and levator operculi have already been sufficiently referred to when describing the opercular bones.

5. LATERO-SENSORY CANALS.

The latero-sensory canals of Trigla differ in no essential particular from those of Scorpaena. As in that fish, the primary tubes branch repeatedly after they leave the bones to which they are related and enter the overlying dermal tissues, large and complex dendritic systems being formed.

The lachrymal lodges three sense organs of the main infraorbital line, the large second infraorbital bone, four organs, and the third and fourth bones one organ each. This makes nine organs in all in this part of the line of Trigla, which is two more than is found in Scorpaena, and one more than is found in Cottus even when counting the small supplemental organ in the second infraorbital bone of that fish.

The postfrontal lodges one sense organ innervated by the oticus lateralis, and the pterotic two organs innervated by the same nerve. The two organs in the pterotic are without intervening primary tube, and are probably, as already explained, in process of condensation into a single organ. The pterotic also lodges a post-preopercular sense organ, innervated by a branch of the supratemporalis lateralis vagi, this organ not being found in Scorpaena but being found in Cottus.

The lateral extrascapular, suprascapular and supraclavicular each lodge one organ of the main line, the organs in the first two bones being innervated by branches of the supratemporalis lateralis vagi, and the organ in the supraclavicular by the next following and single branch of the nervus lineae lateralis vagi.

The supratemporal canal forms a cross-commissure with its fellow of the opposite side, and contains two organs, one lying in the lateral extrascapular and the other in the parieto-extrascapular, both innervated by branches of the supratemporalis lateralis vagi.

The supraorbital canal contains six sense organs, one lying in the nasal and five in the frontal. As in Scorpaena, the fourth primary tube anastomoses in the middle line with its fellow of the opposite side to form a frontal commissure, the penultimate tube anastomoses with the main infraorbital canal between the frontal and pterotic bones, and the primary tube between the fourth and fifth organs of the line has been suppressed.

The preoperculo-mandibular canal anastomoses at its dorsal end with the main infraorbital canal between the pterotic organs that are innervated by the oticus lateralis and the supratemporalis lateralis vagi. It contains eleven sense organs, four lying in the dentary, one in the articular and six in the preopercular, as in Scorpaena, this being one more organ in the dentary and one more in the preopercular than is found in Cottus. The next to the most dorsal organ in the preopercular was nearly always a double organ.

II. Trigla lyra.

In Trigla lyra the granulations on the dorsal surface of the skull are considerably smaller than in T. hirundo, and the striae smaller and more numerous. This gives to the surface a sand-paper-like feel and appearance. The preorbital part of the skull is bent downward somewhat more than in T. hirundo and the skull is everywhere relatively taller than in that fish, excepting only in the anterior half of the snout, where it has the same relative height. On the posterior half of the dorsal surface of the snout there is a large, low, median swelling. The interorbital portion of the dorsal surface of the skull is but slightly concave, and there is, on either side, but one, short and stubby, preorbital spine. The postorbital portion of the dorsal surface of the skull is decidedly convex in transverse section, and slightly convex in median longitudinal section; and there is no slightest indication of a subquadrangular groove.

The rostral depression is relatively larger than in T. hirundo. The nasal rests definitely upon the summit of the anterior palatine process of the ethmoid cartilage, the rounded antero-ventral surface of the latter process articulating with a facet at the base of the maxillary process of the palatine. The anterior edge of this facet on the palatine is raised to form an eminence which gives insertion to the rostro-palatine ligament, and this eminence, lying in front of the palatine process of the ethmoid cartilage, fits in between the nasal above and the ascending process of the vomer below in such a manner that it seems to form part of the articular contact of the palatine with this part of the skull. The lateral edge of the nasal has a sliding articulation with the dorsal surface of the lachrymal, as in T. hirundo.

The ectethmoids suturate with each other in the middle line behind the mesethmoid, as Günther has stated. The orbital surface of the bone includes the orbital surface of the bone in T. hirundo and also that little surface that lies between the two posterior portions of the ridge along the lateral edge of the ventral surface of the bone in the same fish. This condition thus being intermediate between that in T. hirundo and that in Scorpaena.

The median anterior eye-muscle canal, in the antorbital cartilage, so well developed in T. hirundo, is here represented by what is little more than a perforation of the extreme anterior end of the interorbital septum. From there a canal for the olfactory nerve runs forward on either side, this canal being enlarged, as in T. hirundo, to form a deep and large recess in the hind end of the meseth-

moid, the recesses of opposite sides being separated by a thin wall of bone. The mesethmoid extends entirely through the antorbital cartilage, and presents, on the ventral surface of that cartilage, a median circular surface which lies directly upon the parasphenoid; the vacuity found in this part of the bone of T. hirundo not here being present.

The parasphenoid has much the shape that it has in T. hirundo, but the ascending processes are well differentiated, and there is no median process in the interorbital region.

The basisphenoid has a short pedicle which descends only about one half the depth of the myodome, and there terminates with a free end. This free end gives attachment to the middle point of the anterior edge of a stout membrane which extends backward and downward in the middle line, and laterally and slightly downward on either side, and has its insertion on the floor and sides of the myodome. This membrane separates the myodome into two parts, a larger dorso-posterior portion and a smaller antero-ventral one. The dorsal portion lodges the rectus externus, the ventral portion lodging the rectus internus. This membrane, judging from the serial sections of the several fishes that I have examined, must be found in all teleosts, in a more or less developed condition. In Scomber I have already described it (Allis, '03, p. 92).

In other respects there are, in the cranium of T. lyra no important differences from that of T. hirundo.

The hyomandibulo-palato-quadrate apparatus differs somewhat in shape from that of T. hirundo, but in all important respects it closely resembles the apparatus of that fish. The lachrymal is somewhat differently shaped, and its anterior edge is furnished with a number of stout sharp spines. Two bones replace the large second infraorbital bone found in medium-sized specimens of T. hirundo, thus making five bones, in all, in the series.

According to Günther there are six bones in the series, but the specimens examined by him must have been young fish, for in all of my specimens, which are large ones, there are but five bones. The ridge that extends horizontally across the outer surface of the preopercular is much more pronounced than in T. hirundo, and extends forward to that point of the third infraorbital bone from which the striae of the bone all radiate. The dorsal end of the preopercular is prolonged upward and touches and is firmly bound to the outer surface of the hyomandibular, thus forming a closed oval passage through which that part of the dilatator operculi that has its origin in the dilatator fossa passes to reach its point of insertion on the opercular. The spine on the opercular, at about the middle of its hind edge, is much longer and stouter than in T. hirundo.

III. Peristedion cataphractum.

1. SKULL.

The orbital and postorbital portions, together, of the skull of Peristedion, occupy the posterior half only of the total length of the skull, and the posterior third only of the total length of the skeleton of the head. The anterior half of the skull is formed by the long, broad, flat and thin preorbital portion, or snout of the fish, which is straight and inclines slightly downward. The outer surfaces of all the bones are finely granulated, the granulations being arranged, in certain places, but not everywhere, in faintly indicated striae.

The flat anterior ends of the lachrymals form the so-called preorbital processes. These processes are nearly as long as the snout of the fish, and their edges are finely serrated, each little tooth being the end of a vein on the thin edge of the process, this vein appearing both on the dorsal and ventral surfaces of the process as a slight and finely granulated ridge. At the base of the process two ridges begin. The dorsal one is much the stronger and extends backward, across the cheek bones, as a longitudinal, horizontally-projecting shelf, to the hind edge of the preopercular, where it terminates in a tall, thin, obtuse and finely serrated hind end. The anterior half of the ridge bears two groups of small point-like spines; a short anterior group, on the second bone of the infraorbital series, and a long posterior one, on the third bone of the series. Dorsal to the ridge the outer surface of the cuirass of the cheek inclines dorso-mesially, while, ventral to it, it inclines ventrally or ventro-mesially, the ridge making a prominent angle on the outer surface of the cuirass. The ventral ridge is much less important than the dorsal one, and lies near the ventral edge of the cheek bones. It, also, extends to the hind edge of the preopercular, but it is always interrupted, as, or just before, it reaches the anterior edge of that bone, and there usually breaks up into several slightly diverging ridges, all of which are finely serrated their full length.

On the anterior quarter line, approximately, of the dorsal surface of the snout, at about the middle of the length of the nasal bone, there is, on either side, either one stout vertical spine, or two or more smaller spines lying one directly behind the other. On the posterior quarter line of the snout, or even still nearer its base, there is, near the lateral edge of its dorsal surface, on the ectethmoid bone, a group of from one to three similar but smaller spines. Postero-lateral to these latter spines, there are, also on the ectethmoid, two or three short diverging lines of small tooth-like spines. The dorso-mesial one of these lines is continuous with the dorsal edge of the orbit, that edge being serrated. Slightly anterior to the transverse line of the ectethmoid spines, there is, on the dorsal surface of the mesethmoid, a single large median spine.

Starting from the group of ectethmoid spines, on either side, a ridge runs backward to the hind edge of the dorsal surface of the skull, traversing the ectethmoid, frontal and parieto-extrascapular bones. The ridges of opposite sides converge slightly, at first, in a gentle curve, and then run backward in slightly curved and slightly diverging lines to the hind end of the interorbital region, when they again converge slightly to the hind edge of the skull. As they pass between the orbits each ridge lies slightly mesial to the dorsal edge of the corresponding orbit. Each ridge bears a variable number of spines, the spines that lie on the ectethmoid part of the ridge being small and sharply pointed, while the others, on the frontal and parieto-extrascapular portions, are usually serratures that increase gradually in size toward the hind end of the ridge. The large posterior serrature lies on the parieto-extrascapular, extending the full length of that bone and ending almost directly dorsal to the summit of the epiotic. The next anterior serrature is slightly smaller than the posterior one, rises from the hind edge of the frontal, and extends across that part of the frontal that lies posterior to the frontal commissure of the latero-sensory canals. The next anterior serrature is still smaller, is sometimes double, and lies opposite and slightly posterior to the lateral end of the frontal commissure. Beneath the base of this last serrature the sixth tube of the supraorbital canal passes, on its way to join and anastomose with the main infraorbital canal at the edge of the frontal. The fifth tube of the supraorbital canal has been suppressed, as in Scorpaena, the seventh or terminal tube opening on the outer surface of the frontal slightly mesial to the point of this same serrature. This third serrature from the hind end of the line thus has the position, relative to the supraorbital

canal, of the frontal spine of Scorpaena, but it does not lie at the hind end of the frontal, that position being held by the penultimate serrature of the line. Whether this latter serrature represents a part of the frontal spine or not, I can not determine, but it apparently does. The spine on the parieto-extrascapular must then be a parietal spine, and there is no nuchal spine. Starting from or slightly postero-lateral to the frontal spine, and running at first postero-laterally, and then posteriorly, near the lateral edge of the dorsal surface of the skull, there is another ridge, which corresponds in position to the lateral row of spines of Scorpaena. This ridge has a wavy or bluntly serrated edge and sometimes terminates, at the hind end of the suprascapular, in a small spine.

Emery ('85) has given a figure of the skull of the adult Peristedion in which the spines that I have just described are roughly shown, with the exception of the mesethmoid and ectethmoid spines, which are neither shown in the figure nor mentioned in the text. The spines are also shown by the same author in two figures of larvae of Peristedion of different ages, the skull of the youngest larva being said to so greatly resemble the skull of the adult Scorpaena that Emery calls that larva the scorpaenoid stage of the fish. At these two stages of Peristedion the spines are all very large, and a single spine on the nasal, and a single large spine on the frontal represent the several spines on those bones of the adult. A spine is also shown on the pterotic of the youngest larva, this spine being wholly wanting in the adult. Similarly, a spine is said by Emery to be found on the nasal of the young of Trigla hirundo, and to wholly disappear in the adult.

The dorsal surface of the skull of Peristedion, between the fronto-parietal serrated ridges, and posterior to the frontal commissure, is perfectly flat, lies in a horizontal position, and corresponds to the region of the subquadrangular groove on the vertex of Scorpaena. Lateral to the ridge that bounds this surface, on either side, the dorsal surface of the skull is a flat surface that slopes rapidly downward at an angle of approximately 30° to the vertical plane. Between the orbits the dorsal surface is concave. A low rounded ridge, on either side, here marks the course of the supraorbital latero-sensory canal, the two ridges converging forward, in nearly straight lines, toward the median spine on the mesethmoid. In the preorbital region the lateral edge of the dorsal surface of the skull lies, as it does in Trigla, in the level of the ventral surface of this part of the skull; and the line of this edge, prolonged posteriorly, falls, in Peristedion, nearly into the line of the lateral edge of the postorbital part of the dorsal surface of the skull.

The posterior surface of the skull resembles that of Trigla but is steeper, and hence shorter than it is in that fish. The hind edge of the secondary skull is sharp and finely serrated, and slightly ventral to this edge, and parallel with it, there is a slight but sharp ridge which projects posteriorly and forms a little shelf which gives support to the anterior edges of the anterior row of the bony plates of the body. The middle portion of the shelf is formed by the supraoccipital, its lateral portion, on either side, being formed by the parieto-extrascapular and suprascapular. Beneath the ridge, or shelf, there is a slight median vertical ridge which represents the spina occipitalis. This little shelf in Peristedion is apparently simply the ventral edge of the somewhat thickened hind end of the secondary skull of the fish. Ventral to it there is a low and rounded transverse ridge which represents what I have described in Scorpaena and Trigla as the hind edge of the primary skull. Between this ridge and the little shelf that represents the hind edge of the secondary skull, there is a shallow groove which, although it here lies definitely on the hind surface of the skull, evidently represents the supratemporal fossa.

The ventro-posterior limb of the supraoccipital extends ventrally almost to the dorsal margin of the foramen magnum, being separated from that margin by a median bit of cartilage. This exposed bit of cartilage forms the hind end of a median band which separates the dorsal edges of the exoccipitals. The postero-lateral edge of the skull, the edge that separates its posterior and lateral surfaces, is thin, and projects ventro-laterally as a tall ridge. The ventral portion of this edge is formed by the exoccipital and lies in a nearly horizontal position; its dorsal portion, formed by the posterior process of the pterotic, lying in a nearly vertical position. Between these two portions there is a large rounded corner formed by the opisthotic. This gives to the posterior surface of the skull a flattened hexagonal appearance.

The temporal fossa is small and shallow, and on one side of one of the three specimens examined was almost obliterated by the encroaching growth of the bounding bones. The anterior portion of the fossa was especially affected by this contraction, but still remained as a small recess roofed by the small lateral extrascapular.

The dorsal surface of the skull is formed, as in Trigla, by the nasals, mesethmoid, ectethmoids, frontals, postfrontals, sphenotics, pterotics, parieto-extrascapulars, lateral extrascapulars and suprascapulars. All of these bones come to the level of the outer surface of the skull, the exposed portions of all of them being similarly marked by surface granulations. Slightly grooved lines mark most of their contours. Anterior to the nasals, and lying at a but slightly lower level, there is a small rostral depression. The floor of this depression is formed in part by a narrow, thin and smooth projecting plate of the deeper layers of either nasal, in part by the ascending processes of the vomer, and in part by a small intervening portion of the cartilage of the rostrum. The mesethmoid is entirely shut off, by the nasals, from bounding relations to the depression.

The MESETHMOID has an exposed dorsal surface that is usually somewhat lenticular in shape, and the stout, median, mesethmoid spine rises from it, slightly anterior to its middle point. Beneath the superficial, dermo-perichondrial portion of the bone there is a primary portion, of less extensive surface, which extends completely through the cartilage of the snout. In its deeper portion this primary component expands, and becomes a circular plate formed around a point that lies directly beneath the median mesethmoid spine. Between this circular basal plate of the bone and the dorsal dermo-perichondrial plate, there is, on the lateral and posterior edges of the bone, a deep groove; the grooves on the lateral surfaces of the bone being exposed laterally, but the one on the posterior surface lying within the cartilage of the skull. The lateral edge of the dermo-perichondrial component of the bone suturates with the mesial edge of the corresponding component of the ectethmoid, a canal, large anteriorly but small posteriorly, being left between the two bones; the canal lying partly between the primary components and partly between the deeper layers of the dermo-perichondrial components of the bones. The smaller, posterior portion of this canal transmits the supraorbital latero-sensory canal and the ramus ophthalmicus superficialis; the larger anterior portion transmitting that same canal and nerve, and also the nervus olfactorius. A varying number of openings, between the ethmoid bones, lead from the canal to the outer surface of the skull, but they are all closed externally by membrane. Anteriorly the mesethmoid suturates with the nasal bones, and posteriorly with the frontals. Ventrally, its primary portion lies directly upon the dorsal surface of the parasphenoid, the two bones being so firmly attached to each other that they would seem to be in process of ankylosis.

The ECTETHMOID has dermo-perichondrial and primary portions, and resembles, in general shape, the corresponding bone in Trigla. Its posterior surface forms the anterior wall of the orbit. Posteriorly, its superficial component suturates with the frontal, while mesially it suturates with the mesethmoid and nasal, extending forward, along the lateral edge of the latter bone, almost and sometimes quite to the hind edge of a small oval nasal incisure in the lateral edge of the skull. This anterior end of the ectethmoid, when it reaches the nasal incisure, forms only a point in the hind wall of that incisure, and the bone has no other bounding relations to the nasal pit. The mesial edge of that part of the ectethmoid that bounds the nasal bone is grooved, and the lateral edge of the related portion of the nasal bone, that edge of the nasal bone here being grooved on its dorsal surface, fits into the groove on the ectethmoid; the nasal bone thus appearing, in dorsal views, to here underlie the ectethmoid, while in reality it overlies it. Between the dorsal edge of this portion of the ectethmoid and the dorsal surface of the body of the nasal, there is the long and wide groove above referred to, which groove, although it appears to lie between the two bones, lies largely on the dorsal surface of the nasal bone alone. This groove is roofed, in the recent state, by a thin and tightly stretched drum-head-like membrane, which is pierced by several small holes, the groove lodging he anteriorly-directed second supraorbital primary tube, and the several small holes being the pores by which that tube opens onto the outer surface. Similar drum-head-like membranes, perforated by several small holes, are found associated with nearly all of the primary latero-sensory tubes on the head of the fish, but none of them are so large as this second supraorbital one.

The ventro-lateral edge of the ectethmoid presents three regions, one of which forms the anterior half of the edge, and the other two its posterior half. The edge of the bone in the posterior one of these three regions is presented ventrally, in a line that extends posteriorly and slightly laterally, and forms the ventral edge of the lateral portion of the orbital surface of the bone. On the outer surface of this part of the bone there is a smooth surface which gives a sliding articulation to a corresponding surface on the inner surface of the dorsal edge of the third infraorbital bone. Immediately anterior to this posterior portion of the ventro-lateral edge of the bone, there is a short portion which is thickened and rounded to form an articular edge which articulates with a groove on the dorsal edge of what I shall later describe as the dermo-ectopterygoid. Directly mesial to this articular edge, a groove begins on the ventral surface of the ectethmoid and continues forward along the ventral surface of the lateral edge of the anterior half of the bone. The anterior portion of the lateral edge of the bone, lateral to the groove, is rounded. When the cheek bones swing inward the groove receives the dorsal edges of the palatine and dermo-ectopterygoid, and limits the swing of the bones. When the cheek bones swing outward the rounded lateral edge of the ectethmoid enters a groove on the dorsal edge of the lachrymal, between it and the palatine, and limits the swing of the bones in that direction.

A small olfactory canal perforates the antorbital cartilage, mesial to the ectethmoid, lying, in its posterior portion, in the specimens examined, wholly in that cartilage.

The VOMER caps the end of the thin flat and broad cartilage of the snout, and is wholly without teeth. It has a broad thin and delicate body, which lies partly on the ventral surface of the cartilage of the snout and partly on the ventral surface of the parasphenoid, and two short wide and somewhat stouter ascending processes which lie on the dorsal surface of the cartilage of the snout and come into contact, posteriorly, with the anterior edges of the ventral plates of the nasals.

There is a broad rounded incisure between the two ascending processes, the incisure embracing the anterior end of a small median interspace of cartilage which lies between this incisure and a median incisure between the adjoining anterior edges of the ventral plates of the nasals. Directly anterior to the incisure in the vomer, there is a very small median eminence on the anterior edge of the bone, and midway between this eminence and the lateral edge of the bone there is a larger eminence, also on the anterior edge of the bone. Running dorso-laterally from this latter eminence there is a slight ridge which terminates in an eminence on the dorsal surface of the ascending process of the bone. Lateral to this ridge and eminence there is a broad and shallow groove which gives articulation, through the intermediation of a pad of tough fibrous tissue, to the postero-mesial surface of the ascending process of the maxillary. Lateral to this articular groove, the ascending process of the vomer bounds and supports the anterior palatine process of the ethmoid cartilage.

The ROSTRAL is pyramidal in shape, as in Trigla, and gives support, on its anterior surface, to the ascending processes of the premaxillaries. Its internal surface rests upon the little median interspace of cartilage on the dorsal surface of the snout, and also on the adjoining portions of the ascending processes of the vomer. This interspace of cartilage lies considerably anterior to the nasal pits, as it does in Trigla, instead of being internasal in position, as it is in Scorpaena.

Whether there is in Peristedion, as in Trigla, a diverticulum of the nasal sac of either side that extends into the rostral depression, was not investigated; but it would seem not, the space beneath the anterior end of the nasal seeming too small to permit it.

The PREMAXILLARY is a slender untoothed bone, with a large flat and thin postmaxillary process, and small ascending and articular processes. The proximal end of the shank of the bone is bent so as to project postero-ventrally and slightly mesially, and from the base of this bent portion the short ascending process arises; this process and the proximal end of the bone together forming a straight edge, and together looking like the flattened and broadened proximal end of the bone. This straight edge of the bone lies close to its fellow of the opposite side, the ascending process being directed dorso-anteriorly instead of dorso-posteriorly. From the dorso-anterior end of the process, or from the rostral immediately posterior to it, a ligament arises, and running ventro-postero-laterally is inserted on the maxillary at the base of the ascending process of that bone. This ligament is apparently the homologue of one half of the rostro-palatine ligament of Scorpaena and Trigla, the other half of the ligament arising on the maxillary, close to the point of insertion of this one, and extending from that bone to the palatine. The articular process of the premaxillary is small, is directed dorso-posteriorly, and articulates with a large but low articular eminence on the anterior surface of the proximal end of the maxillary.

The MAXILLARY has a slender shank, with its distal end abruptly expanded. On the anterior surface of the proximal end of the bone there is a large oval eminence which gives articulation to the premaxillary, the long axis of the eminence being directed dorso-distally across the anterior surface of the bone. From the dorsal edge of the bone, in the line of the axis of the articular eminence, the ascending process of the bone arises, the process lying transverse to the shank of the bone and being directed dorso-postero-laterally. The postero-ventral edge of the process is thickened, and has a sliding articulation with the dorsal surface of the ascending process of the vomer, in the groove already described, the articulating surfaces being separated by a pad of tough fibrous tissue. In the angle between the distal surface of the process and the shank of the bone, is the articular surface for

the anterior end of the maxillary process of the palatine. This process of the palatine is, as in Trigla, closely bound to the dorso-mesial edge of the lachrymal, and from the adjoining edges of these two bones a strong ligament arises and has its attachment on the dorsal surface of the maxillary. This ligament, as already stated, apparently represents the distal half of the rostro-palatine ligament of Scorpaena. The ethmo-maxillary ligament is represented by a short ligament that extends from the ascending process of the maxillary to the ventral surface of the nasal, at the base of its process-like antero-lateral corner. There is no ligamentary process either on the external or internal surface of the bone, this doubtless being in causal relation to the slightly developed condition of the maxillo-mandibular ligament and of that tendon of the adductor mandibulae that has its insertion on the maxillary.

The NASAL is a flat quadrilateral bone, which rests, in large part, directly upon the dorsal surface of the thin flat anterior portion of the antorbital cartilage. In the anterior two-thirds of its length it suturates, in the middle line, with its fellow of the opposite side. Posteriorly it diverges slightly from the middle line, leaving a V-shaped space between itself and its fellow of the opposite side, this space receiving the pointed anterior end of the mesethmoid. The narrow hind end of the bone suturates with the mesethmoid, slightly overlapping that bone externally. Laterally, the posterior half of the bone suturates with the long anterior end of the ectethmoid, in the manner already described. The dorsal surface of this part of the bone is deeply grooved, near and parallel to its lateral edge, for the second primary tube of the supraorbital lateral canal, as also already described. A narrow wall of bone alone separates the extreme anterior end of this groove from the hind end of the nasal incisure. The antero-lateral corner of the bone is prolonged into a short stout horn-like process which rests upon the summit of the anterior palatine process of the ethmoid cartilage. On the lateral surface of the anterior end of this process there is the large opening of the anterior primary tube of the supraorbital latero-sensory canal, this tube opening on the outer surface by a single large pore. The bone is traversed by the supraorbital latero-sensory canal, and lodges one organ of the line.

The lateral half of the nasal is thickened, its full length, and this thickening would seem to be due to the fusion, with the usual dermal component of the bone, of a thin underlying plate of bone. This underlying plate lies directly upon the cartilage of the snout, and projects slightly beyond the overlying portion of the nasal, both anteriorly and laterally. The laterally projecting portion of the plate forms the floor of the nasal pit, while the anteriorly projecting portion overlaps externally the hind edge of the ascending process of the vomer. The antero-lateral corner of the plate lies directly beneath but is separated by a very narrow slit from the process-like antero-lateral corner of the dorsal, dermal portion of the bone, and here approaches and gives support to the base of the but slightly developed anterior palatine process of the ethmoid cartilage. This latter process forms, as in Trigla, the antero-lateral corner of the thin flat cartilage of the snout.

The ventral plate of the nasal of Peristedion thus occupies somewhat the position of the corresponding half of what I have described, in Trigla, as the perichondrial portion of the mesethmoid of that fish. It also occupies much the position of the plate that I have described, in Belone, as underlying the dermal component of the nasal of that fish. In Peristedion, as in Belone, it separates from the underlying cartilage, in slightly boiled specimens, without breakage of the cartilage, and hence would seem to be of membranous origin, but this was not carefully investigated. Two suppositions suggest themselves regarding it. The one, that there is a predisposition in the tissues of this region to the development of this plate, and that the plate attaches itself to the mesethmoid or nasal,

according as the one bone or the other covers the region; and the other, that the anterior palatine process of the ethmoid needing support, a supporting plate is developed from the nearest bone available.

The FRONTAL has nearly straight mesial and hind edges, lying at a right angle to each other. It has a small ventral flange, resembling somewhat, but much smaller than that of Scomber. Posterior to this flange, on the ventral surface of the bone, there are two slight ridges, meeting at an angle, which form, as the similar but more developed ridges of Scomber do, the antero-mesial and antero-lateral boundaries of the anterior end of the lateral cranial fontanelle. The frontal suturates mesially with its fellow of the opposite side, posteriorly with the parieto-extrascapular, and laterally with the pterotic, the postfrontal, and a small corner of the sphenotic that comes to the level of the outer surface of the dermal bones. It is traversed by the supraorbital latero-sensory canal and lodges five organs of that canal, which are similarly disposed to those found in Scorpaena and Trigla; that is, the second, third and fourth organs of the line are in regular positions; the fourth and fifth organs lie close together without intervening primary tube; and the sixth organ is a small one lying in the small terminal tube of the line and innervated by a nerve that first issues in the orbit and then perforates the alisphenoid to enter the cranial cavity and perforate the frontal beneath the organ it innervates.

The POSTFRONTAL is a small bone that forms the roof of the small dilatator fossa, and is bounded mesially by the frontal, posteriorly by the pterotic, and anteriorly by the dorso-lateral corner of the sphenotic. It is traversed by the dorsal end of the postorbital portion of the main infra-orbital canal, and lodges one organ of that canal, innervated by the ramus oticus lateralis.

The PARIETO-EXTRASCAPULAR forms part of the hind edge of the secondary skull, and its hind edge is thickened and grooved, as already described. The bone suturates anteriorly with the frontal, and laterally with the pterotic, lateral extrascapular, and suprascapular, not overlapping dorsally the epiotic process of the latter bone. It lies directly upon the supraoccipital, the epiotic and the adjoining cartilaginous portions of the roof of the cranium, its lateral edge forming part of the roof of the temporal fossa. Its hind edge is traversed by the supratemporal commissure of the latero-sensory system and lodges one organ of that commissure.

The LATERAL EXTRASCAPULAR is a small subcircular bone lying between the fronto-parietal and lateral spinous ridges, wedged in between the pterotic, parieto-extrascapular and supra-scapular bones. It forms part of the roof of the temporal fossa, but does not come to the lateral edge of the skull, being shut off from that edge by relatively wide suturating portions of the pterotic and suprascapular. It is traversed by the lateral portion of the supratemporal latero-sensory commis-sure and lodges one organ of that commissure. It is not perforated by the main infraorbital canal, as in the other fishes described, the canal here simply passing along the lateral edge of the bone, partly enclosed in it, and there apparently being no organ of the main infraorbital line related to it. In this Peristedion resembles Dactylopterus, as will be later described.

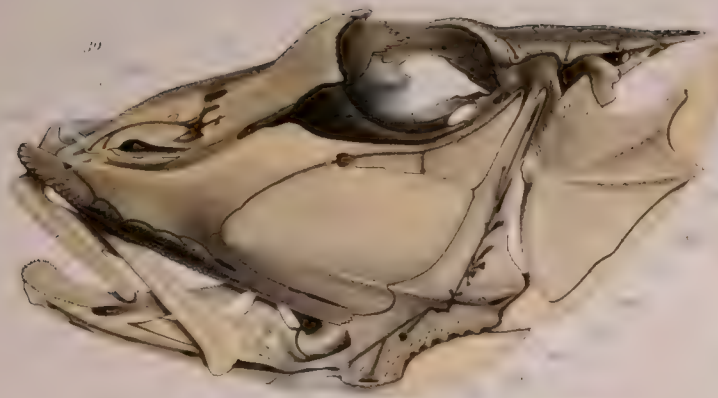
The SUPRASCAPULAR forms the postero-lateral corner of the dorsal surface of the skull, and the larger part of the roof of the temporal fossa. It has a well developed opisthotic process, but no differentiated epiotic process, that part of the bone that represents that process being relatively short and appearing as an epiotic region rather than an epiotic process of the large body of the bone. On the ventral surface of this epiotic region of the bone there is a small ventral process, and this process and the adjoining portion of the mesial edge of the bone suturate with the hind end of the suprascapular process of the epiotic. The anterior edge of this part of the bone suturates with the

lateral edge of the parieto-extrascapular, that bone not overlapping the suprascapular at all. The remainder of the anterior edge of the bone suturates with the lateral extrascapular and pterotic. The bone is traversed by the main infraorbital latero-sensory canal and lodges one organ of that canal. The canal leaves the bone by a large opening on its lateral edge, near its hind end, and immediately anterior to this opening, on the ventral surface of the bone, the wide stout opisthotic process arises. Immediately postero-mesial and also immediately postero-lateral, to the hind edge of the base of the opisthotic process, there are small articular facets. These two facets give articulation to two articular eminences on the dorsal edge of the supraclavicular, these eminences embracing the hind edge of the opisthotic process of the suprascapular. From the deep layers of the hind edge of the epiotic region of the bone there projects postero-mesially a thick plate of bone which gives support, on its dorsal surface, to the first one of the series of dorsal plates on the body of the fish.

The SUPRACLAVICULAR is a somewhat triangular bone, the external surface of which is slightly concave and partly covered with small granulations. On its short dorsal edge, which represents the base of the triangle, are the two little eminences, above referred to, which articulate with the suprascapular. Posterior to these eminences, the dorso-posterior corner of the bone is traversed by the main latero-sensory canal, and lodges one organ of that canal. The ventral end of the bone is pointed, instead of being expanded as in Trigla, but, as in that fish, it overlaps externally and is bound to the dorsal end of the clavicle; and, excepting that the bone is relatively smaller than in Trigla, there is nothing abnormal in its position or relations to the other bones.

The PARASPHENOID has the shape shown in the figures. The ascending process of either side rises at about the posterior quarter of the length of the bone, and is a thin triangular plate that lies transversely to the axis of the bone instead of parallel to that axis. The point of the triangle is directed upward and the base downward, and from this base of the triangle a thin flange of bone extends forward along the lateral surface of the bone. The mesial edge of the triangle is thickened somewhat, is directed dorso-latero-posteriorly and terminates in a sharp point; and this thickened part alone of the triangle would seem to be the homologue of the entire ascending process of the bone in the other fishes so far described, for it alone lies between the anterior edge of the posterior portion of the body of the bone and the hind end of its thickened interorbital portion. The triangular plate can accordingly be considered as a thin flange of bone that arises from the lateral surface of the ascending process proper; this flange projecting laterally and slightly posteriorly, and, at the ventral end of the process, being bent forward, in a rounded angle, and then continued forward as a flange that projects laterally and slightly ventrally from the ventral edge of the lateral surface of the interorbital portion of the bone.

On the dorsal surface of the interorbital portion of the parasphenoid, two thin laminae of bone arise, and converging posteriorly, unite, slightly anterior to the ascending processes of the bone, to form a median tooth-like process. The triangular space between the two laminae lodges, as in Trigla, the ventral end of the cartilage of the interorbital septum, the hind end of the process giving attachment to membrane that represents the leg of the basisphenoid; that bone being wanting in Peristedion. On the dorsal surface of the posterior portion of the parasphenoid there is a median longitudinal raised portion which is deeply grooved on its dorsal surface. This raised portion fills the hypophysial fenestra, the groove on its dorsal surface forming part of the floor of the myodome. The hypophysial fenestra extends backward slightly beyond the anterior edge of the basioccipital.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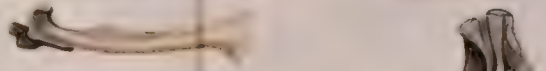
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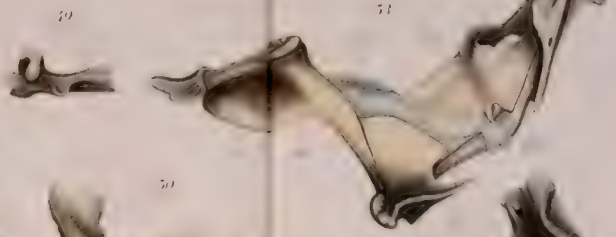
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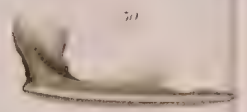
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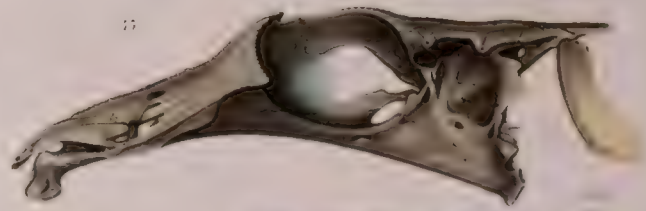
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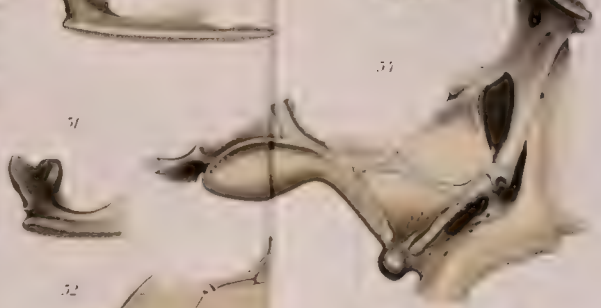
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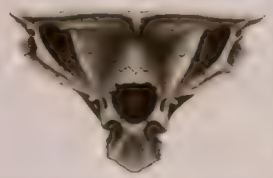
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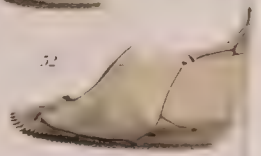
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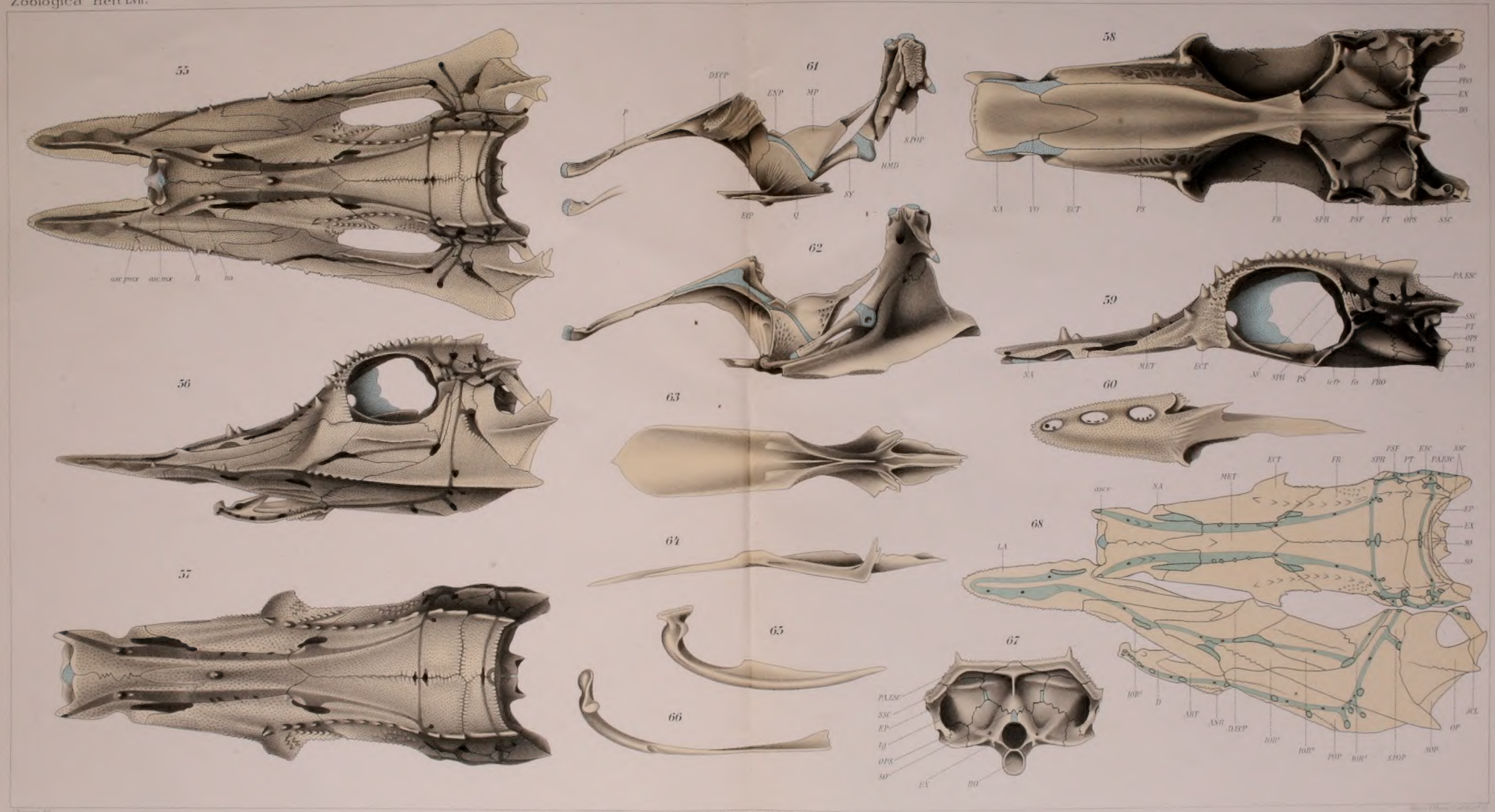
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